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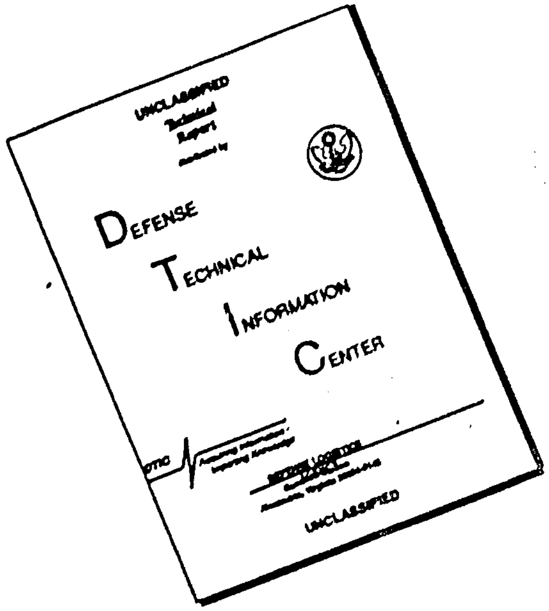

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D Ireton

Donna Ireton
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# PROGRAM MANAGEMENT

PROGRAM MANAGEMENT

**A Missile Program Office Exercise—Using MBTI-Balanced Teams**

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Industrial College of the Armed Forces

**ABSTRACT**

Wouldn't it be remarkable if we could speculate--accurately--how a small group of people would perform on an assigned task? Or if we could objectively evaluate their performance? Wouldn't it be even more remarkable if all this could be done in a program office (PMO) environment?

It sounds too good to be true, yet the concept was demonstrated at the Industrial College of the Armed Forces (ICAF), with 220 senior military officers and civilians participating in a five-week exercise. The subject? Acquisition of a surface-to-surface missile system.

The participants were divided into four and five person groups. Each one took its missile system from concept exploration through production and deployment. They encountered many of the same decisions that would be made in a real program office. The difference was that each of the 50 teams were structured by psychological type using the Myers-Briggs Type Indicator (MBTI). Team performance on the exercise was measured, then compared with how well they fared against one another.

As you can imagine, many questions have arisen about the results of this research: Does it make any difference what type people are in a group? Do certain groupings of people in a PMO environment yield better (or worse) results than others? Is there a "collective" psychological nature about the members of a group? Do any relationships (correlations) exist between performance and the characteristics of groups?

All of these have come out "yes" so far.

**INTRODUCTION**

The basic idea of this research was to explore the idea that a small group of four to six people had a "collective" psychological type, and that certain assertions could be made about the functioning and performance of the group as a result of its "collective" type. The purpose of the study was to evaluate psychological type and its relationship to group performance (Figure 1).

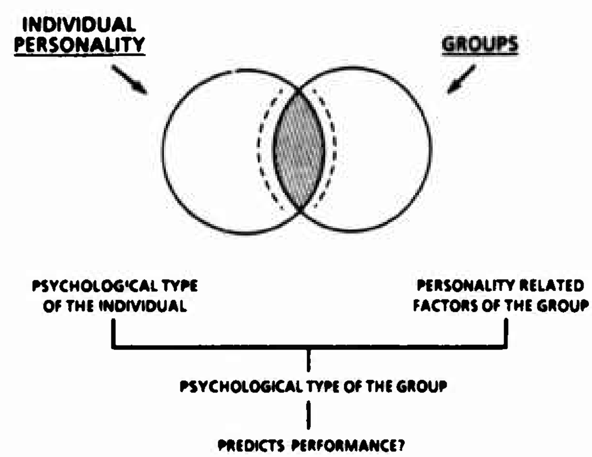



Figure 1. Psychological Type of the Group

The research was conducted at the Department of Defense's National Defense University--ICAF--in Washington, D.C. A sample of 50 groups, comprised of senior military officers and government executives, participated in a systems acquisition exercise. Each student's MBTI was known, and teams were structured in sizes up to six members each--the norm being five--with prior acquisition experience intentionally balanced among the teams. Some teams were formed randomly, while others were arranged so they would be (nearly) homogeneous according to MBTI. The objective was to assure that team composition was varied in order to provide a range of differences among teams. Team members were assigned responsibilities similar to those of the senior leadership of a real program office. One was designated the program manager (PM).

| | | |
|---|---|---|
| Extravert | ............0............ | Introvert |
| Sensing | ............0............ | Intuitive |
| Thinking | ............0............ | Feeling |
| Judging | ............0............ | Perceiving |

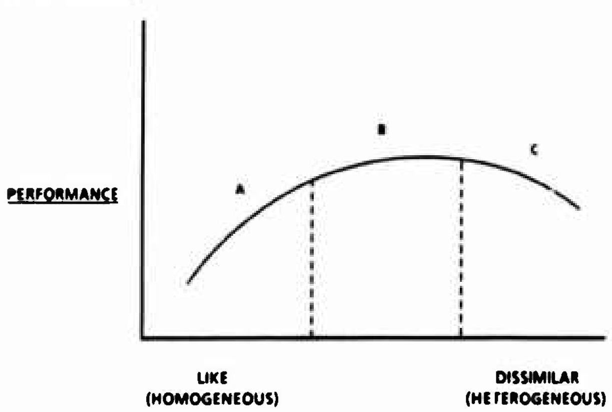
Figure 2. The Four MBTI Dimensions

For each MBTI dimension--EI, SN, TF, and JP (Figure 2)--a team's average continuous scorel was computed. Mean continuous scores allowed the classification of teams into a "collective" MBTI. Similarly, the standard deviation (as a measure of a team's diversity) was computed for each MBTI dimension for each team.

The exercise had a number of decision points, at which an effectiveness index was computed for each team. The change in this effectiveness index from the first to the last decision point was the objective measure of performance for each team. The index was computed by appraising the three critical factors found in any weapon systems acquisition: the funds expended (cost), the time taken (schedule), and the performance achieved.

Students were also asked to complete a 27-question survey about various aspects of their team's participation and involvement during the exercise. Additionally, each team was observed by a faculty member who provided an assessment of team performance, actions, and activities. Both the student survey and faculty observations yielded subjective measures of team performance, against which the objective performance data were also compared.

At the outset of the study I had conceived a relationship existing between (1) group performance and (2) the likeness (or dissimilarity) of members of a group. Figure 3 depicts this relationship as I envisioned it:



The Group's Type

Figure 3. "Collective Type" vs. Performance

I anticipated that groups within these three categories would perform roughly as follows:

[A] Because of similarity, more cohesion, but less discussion; agreement occurring easily; issues and alternatives not thoroughly discussed; result: marginal performance

[B] A modest degree of conflict exists--the right amount; issues discussed, alternatives surfaced; yields the best performance

[C] Because of dissimilarity, too much dissension, conflict, and disagreement; result: poor performance.

So there were several elements to be considered and evaluated:

- Team Performance, as determined by an effectiveness index based on cost, schedule, and performance
- The average (mean) and standard deviation of each team's MBTI--on all four dimensions
- Each student's opinion about (a) himself and (b) the functioning of his group
- The conclusions drawn by faculty members about the groups they observed.

## ANALYSIS: WHAT HAPPENED?

Performance and MBTI

Team performance, using the effectiveness index already discussed, was correlated with a team's average (mean) MBTI scores for each dimension, with the following results:

| Preference | $r_s$ | p< |
|---|---|---|
| Extravert-Introvert (EI) | .23 | .1 |
| Sensing-Intuitive (SN) | .23 | .1 |
| Thinking-Feeling (TF) | .24 | .1 |
| Judging-Perceiving (JP) | .30 | .025 |

The results seem to indicate that a positive relationship (correlation) exists between higher performance and higher continuous MBTI scores, i.e., when teams are more I than E, more N than S, etc., they perform better.

A question that surfaces is how good is good in correlation. A rough rule-of-thumb for evaluating the magnitude of a correlation coefficient is: "a correlation that is less than 0.30 is small, a correlation that is between 0.30 and 0.70 is moderate, and a correlation that is between 0.70 and 0.90 is large...." It should be added that although such rules provide a guideline, they can be misleading in specific situations. One really must know what is **typical.**2

Given the nature of this research, an [$r_s > .30$] was deemed worthy of being noted and considered for future testing. On this basis, the only relationship of significance occurred on the JP dimension. However, when the means of the four dimensions were summed and correlated with performance, a "collective" type emerged--a critical and noteworthy "first"--that both justifies and requires further testing:

| | | |
|---|---|---|
| EI + SN + TF + JP (combined) | .35 | .01 |

MBTI Preferences and Acquisition

Results associated with the **EI dimension** are explained by recalling the definitions of extravert and introvert. Extraverts prefer processes in the outer world of people and things. Introverts favor work in the inner world of concepts and ideas. Sixty percent of all team members were Introverts. The acquisition process--particularly during the early phases--exists on a conceptual plane. It is not yet the real world of actual things and people, but rather a future world of ideas and capabilities to come. Hence, it is not surprising that with such a large percentage of Introverts, the EI dimension surfaces in a correlation that predicts performance.

Sensing types (on the **SN Dimension**) are good at gathering facts. However, Intuitives deal with meanings, relationships, and possibilities that are beyond the reach of the senses. Again, the nature of the acquisition process seems to demand the natural propensity of the Intuitive toward dealing with the abstract. Systems not yet in existence are more difficult to "sense" for the Sensing type. Consequently, Sensing types would be at a disadvantage in this process. The results seem to confirm this.

Since the exercise is one of decision-making, the **TF dimension** seems to be an appropriate one to focus on. Thinking types like analysis and putting things in logical order. They tend to decide impersonally, sometimes paying insufficient attention to people's wishes; they are more analytically oriented. The pure acquisition process offers the textbook opportunity for dispassionate analysis--a task befitting a Thinking type. Over ninety percent of the participants in the exercise were Thinking types. Consequently, for exercises like this, one could theorize that in a group of mostly Ts, performance would be associated with a measure of the group's Thinking dimension.

The relationship between team means on the **JP dimension** had the highest correlation with performance, but the cause and effect of this relationship is not clear. It seems to indicate that teams with higher mean continuous scores, i.e., tending more to Perceiving than Judging, performed better on the exercise. One conclusion implied from these results is that there is a greater tendency to explore alternatives among teams with a preference for Perception rather than Judging.3 An explicit conclusion is that they did perform somewhat better.

Performance and Diversity

Similarly, the standard deviations (s.d.) of continuous MBTI scores for each team were correlated with performance. The relationship of team performance with this measure of team dispersion on each of the MBTI dimensions is shown below:

| | | |
|---|---|---|
| Extravert-Introvert (EI) | -.24 | .1 |
| Sensing-Intuitive (SN) | .35 | .01 |
| Thinking-Feeling (TF) | -.33 | .025 |
| Judging-Perceiving (JP) | -.07 | - |

The standard deviation of each team's continuous score was computed to obtain the amount of dispersion for each dimension. Three of the four were negative, i.e., as the standard deviation --team dispersion--increased, performance decreased. Said another way, as team members became more alike on the EI and TF dimensions, i.e., where scores clustered closer and closer to the team mean, performance increased.4

Conversely, teams that had large amounts of dispersion from the team mean performed worse. This suggests that group performance is influenced by the mix of strengths on these MBTI dimensions. Teams whose members displayed wide swings in continuous scores on EI and TF seemed to have performed less well.

One correlation was positive. As the standard deviation of MBTI continuous scores on the SN dimension increased, performance increased. Despite several hypotheses derived from observing the data, no statistically significant conclusion could be drawn that fully explains this relationship.

## CONCLUSIONS

The author acknowledges that there are limits to this study: it was conducted in a specific environment--the National Defense University, and with a particular sample--military officers and government executives. This is obviously a unique, contextual group of people. Nonetheless, there are extrapolations from the data that raise serious questions appropriate for continuing research. One in particular relates directly to the program office environment.

Many managers support the theory that heterogeneous groups will produce more alternatives and better quality decisions than homogeneous ones. They acknowledge that, although groups with diverse membership structure may expend more energy during the formation process, the end product is enhanced as a result of a group's diversity. Before I began this research, I concurred with this notion (See Figure 3). But I don't any more. My results simply don't support the idea that diverse working groups are better producers than homogeneous ones.

It leads me to question assumptions about the desirability of heterogeneous groups, and even raises some interesting questions about group decision making and performance. I'm suggesting that managers ought to consider (1) Norman Maier's Principle 6, and then (2) my approach to the group and how it might better function in the problem-solving environment.

> The "idea-getting" process should be separated from the "idea-evaluation" process because the latter inhibits the

former. "Idea-evaluation" involves the testing and the comparison of solutions in the light of what is known, their probability for succeeding, and other practical considerations. It is the practical side of problem solving and is the phase of problem solving when judgment is passed on solutions. "Idea-getting" requires a willingness to break from past experience. It is this process that requires an escape from the bonds of learning and demands that we search for unusual approaches and entertain new and untried ideas.5

Problem-solving: Two Phases

My research efforts suggest a somewhat similar approach--that there should be two phases to the group problem-solving process. The earlier is the Diverging or "Brainstorming" segment, followed by a Converging or "Implementation" phase (Figure 4). The first occurs during Maier's "idea-getting" stage, where people, according to my data, with one or more of the following MBTI preferences seemed to contribute to better group performance: Introversion, Intuition, Thinking, and Perceiving.

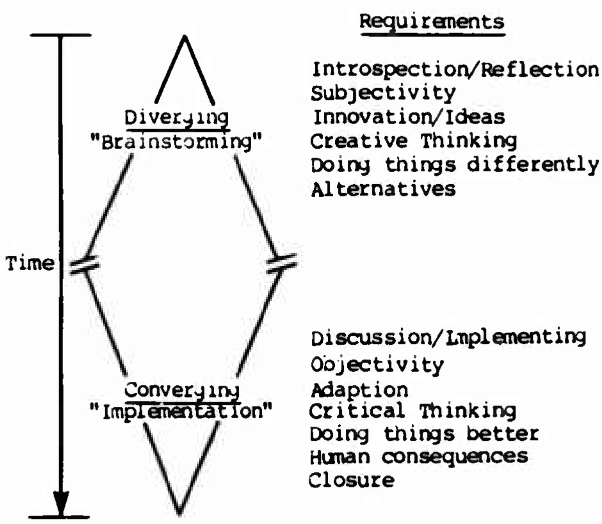



Figure 4. MBTI and Problem Solving

My experiment with 50 groups indicated that minimum diversity among group members on the Introversion and Thinking dimensions provides better results early-on in the acquisition process. Additionally, the strong influence of Intuitives and Perceiving types aids in the innovation and creativity required during the "diverging" portion of a problem-solving scenario. This would apply to the ad hoc or brainstorming group conducting a study or searching for an idea or solution.

The "Implementation" phase is a different story. During the Converging part of the problem-solving process, a further extrapolation of the data suggests that Extraversion, Sensing, Feeling, and Judging preferences are better suited to the requirements at this time. After the generation of a number of ideas, there comes a time to shift to "idea-evaluation" and closure.

R.M. Belbin, the noted British business-team educator, concurs with this approach. He advocates setting up two teams, one to generate ideas and the other to evaluate them.6 This suggests using a pair of teams for problem-solving--a "first half" team made up of I, N, T, and P MBTI preferences, followed by a team for the "second half" comprised of E, S, F, and J preferences. One or two members might even "go 60 minutes" with both teams so there would be a "corporate memory" between the two.

**SUMMARY**

The dispersion (standard deviation)--rather than the mean--of a group's combined preferences appears to be critical on certain MBTI dimensions. Research concentrating on all four--means on some and variances on others--has the potential of reawakening the homogeneous vs. heterogeneous group debate, and the kinds of groups that are most productive during various phases of problem-solving.

Where is this type of small group research at? The "concept exploration" phase of the project is over, and the first "qual test" in D/V has been accomplished. What's required now is an operational test of small work groups in a real PMO (or some other place having small work groups) to further validate the concept and preliminary findings.

The potential for this type research in the acquisition community is enormous, primarily because it's not been looked at in this way before. It's a recognized fact that PMs want to get the best out of their people, whether it's a special working group or an ad hoc task force--or just the customary group interaction in the PMO. This concept has the possibility of being one of those forward-looking vehicles to enhance the critical and productive use of manpower in the program office.

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(1) So that researchers do not have to carry alphabetic symbols (E, I, etc.) in their research computations, a single number is used to denote the valuation of an individual's preference. This is known as the "continuous" score and is simply a transformation of the "preference" score. It's accomplished by setting the midpoint at 100 instead of at 0. For example, a preference score of E-21 becomes a continuous score on the EI dimension of 79; an I-31 becomes a 133. This conveniently eliminates the need to carry alpha characters in statistical analyses. (Myers, Isabel Briggs, and McCaulley, Mary H., Manual: A Guide to The Development and Use of the Myers-Briggs Type Indicator, Consulting Psychologists Press, Palo Alto, CA, 1986, pp. 224-226.)

(2) Jaeger, Richard M., Statistics, A Spectator Sport, SAGE Publications, Beverly Hills, CA, 1983, p. 74.

(3) This latter preference, Judging, would seem to be in greater demand later in the problem solving process, offering a propensity for closure, execution, and implementation.

(4) The sum of the standard deviations on the EI and TF dimensions produced one of the highest associations found in the study [$r_s = -.39$, $p<.005$].

(5) Maier, N. R. F. "Leadership Principles for Problem-Solving Conferences," Organizational Psychology: Readings in Human Behavior in Organizations, Edited by David A. Kolb, Irwin M. Rubin, and James M. McIntyre, Prentice-Hall, Englewood Cliffs, NJ, 1984, p. 182.

(6) Belbin, R. Meredith, Management Teams: Why They Succeed or Fail, Halsted Press/Wiley, New York, 1981, p. 32.

# FOSTERING IMPROVEMENT IN THE QUALITY OF MANAGEMENT DATA

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## ABSTRACT

The twelfth and final principle in the statement of DoD Posture on Quality is: "Principles of quality improvement must involve all personnel and products, including the generation of products in paper and data form." Improving the quality of data has important implications for measuring performance. To improve quality you must control performance. Control of performance implies measurement of performance. Accurate measurement is needed for effective control. Based on the experience of analysts in the U. S. Army Contracting Support Agency during a recent project involving four Army installation contracting offices, it is apparent that significant improvements must be made in the process of originating, recording and analyzing contracting workload and performance data.

Essential actions needed to improve the quality of products in data form are:

-Standardizing definitions for data elements and measures of performance being used throughout DoD

-Communicating standardized definitions to all involved in the process of data generation, processing and analysis

-Appropriate training at all levels to educate personnel about the use of data and to instill the importance of data accuracy

-Applying internal controls to provide assurance of data quality

-Automating operations to the maximum extent practicable

-Incorporating accuracy of records as an element of performance standards and giving systematic feedback on performance


## INTRODUCTION

The fast pace of change in office technology and the wider and quicker dissemination of information has reinforced the requirement for data to be correct. Today, data is being processed in nanoseconds and shared with others by transmission over telephone data lines at the rate of thousands of characters per minute. The quality of data available is critical to the quality of decisions made by everyone from operating manager to top executive. Ever increasing demands make it more important than ever that time not be wasted studying data that are inaccurate. Thus, it is appropriate that the statement of DoD Posture on Quality includes emphasis on improving the quality of products in data form. According to the twelfth and final principle in that statement: "Principles of quality improvement must involve all personnel and products, including the generation of products in paper and data form." (3) Improving the quality of data has important implications for measuring performance.

## THE PROBLEM

One important habit that consumers of management data must develop is that of questioning the data. Numbers and letters spawed from computers are not guaranteed to be accurate. Based on input and software, those data are subject to errors just as calculations using pencil and paper are. People must overcome the tendency to give greater credibility to data just because they are processed by a computer. If data do not make sense, then they should be questioned until the information has been validated no matter what process created the numbers.

Questioning of data was a critical part of a project the U.S. Army Contracting Support Agency (USACSA) recently concluded. That project was designed to increase the effectiveness and efficiency of installation contracting by developing prototype contracting offices. During analysis of data collected, it was discovered that the quality of existing data collection and retrieval systems at the four sites selected for the project was unacceptable. (USACSA analysts collecting data from other offices have found similar problems.) None of those offices had an internal control system in place to assess the accuracy of data entered on registers or into the automated system. Consequently, the most time consuming part of the project was the iterative process of data collection, review, analysis and correction.

The type of information collected for the project included data on purchase requests received, returned and awarded; procurement actions and dollars awarded; procurement administrative lead time and productivity . Data were stratified using various characteristics of the actions such as dollar value, type of procedures used (simplified purchase or other), type of purchase (supplies, services or construction), type of solicitation (sealed bid or negotiated) and whether or not full and open competition was obtained.

During review and analysis of the data, errors became apparent. Work reported to have been received during the year remained unaccountable at the end of the year. Monthly calculations of work on hand made by adding receipts to the previous end-of-month balance and subtracting work completed or returned did not equal the amount of work reported to be on hand at the end of the month. In addition, duplicate awards of purchase requests were found among the records examined.

For analysis, classification of contracts as supplies, services, or construction was based on the FSC or Service Code assigned for the Individual Contracting Action Report (Over $25,000) (DD 350). Not all offices interpret the coding instructions the same way. Family housing maintenance was coded as services at one installation and as construction at another. As another example, leasing of vehicles was coded as supplies by one office and as services by another. Another classification problem arose because not all offices use the same procurement instrument identification numbering system. Some adopted the system established by the Defense Federal Acquisition Supplement; others adapted it.

Most of the errors occurred in recording dates--purchase request receipt dates, solicitation issue dates, solicitation open/close dates and award dates. Dates had been recorded which indicated that awards were made before purchase requests were received, solicitations were opened/closed before purchase requests were received, solicitations were opened/closed before they were issued and awards were made before solicitations were opened/closed.

Man-hour data collected to compute productivity were subject to misinterpretation. In some offices TDY and training are included in productive man-hours; at others, that time is excluded. Some offices include holidays in available hours while others do not. Some offices track time for supervisors, leaders, clerks and purchasing agents separately but others do not. To make valid comparisons, the analyst must restructure the data.

Additional problems were noted in compiling data for the Monthly Contracting Summary of Actions $25,000 or Less (DD 1057) and the Individual Contracting Action Report (Over $25,000) (DD 350). Both of these reports are sources of data for the Federal Procurement Data System. Error rates are consistently high and transactions go unreported. Problems with submission of DD 1057 and DD 350 data plague not only the Army but the Air Force as well. One of the six Blanche Witte Memorial Awards for 1988 given by the National Contract Management Association went to an Air Force Headquarters Staff Procurement Analyst who successfully attacked a major problem with these procurement reports. Betty O'Brien identified significant data discrepancies in DD 350s and DD 1057s resulting in errors affecting thousands of procurement actions and involving tens of millions of dollars. (1:22-23) Procedural problems, inadequate internal controls and inadequate training all contributed to these errors. (2)

## EFFECT OF ERRORS

In the area of installation contracting, inaccurate data are giving a false picture of historical workload, frustrating efforts to document productivity improvements resulting from automation and jeopardizing progress toward securing adequate staffing. An accurate data base from which to measure the effect of changes designed to improve contracting operations is vital to documenting progress in acquisition reform.

As use of current technology advances and data are shared among more and more organizations, both the importance of data accuracy and the adverse effect of inaccurate data increase. As growing numbers of systems are interfaced or integrated, the introduction of inaccurate data at a single point can create major problems in other functional areas. The time and effort required to correct errors in the various data bases and to track the products produced from those data bases grows. Slimmer budgets coupled with greater demands are compelling reasons to get it right the first time.

Some supervisors comment that they do not have time to be concerned with keeping accurate records and computing correct statistics on their work because they are too busy doing it. They must come to the understanding that accurately accounting for and reporting the work being done is an integral part of managing that work. To improve the quality of work done under their direction, supervisors must control performance. Control of performance implies measurement of performance. Accurate measurement is needed for effective control.

## REASONS FOR ERRORS

When an error in data is encountered, it is not enough to just correct the information for that particular instance. Someone must be responsible for investigating the reason for the data deficiency and assessing the probability that other data may also be incorrect. If the inaccuracy is an indication of a systemic problem, then a plan must be put in place for improving the accuracy of that data in the future.

Based on the work the USACSA did with the four prototype offices, the most frequent reasons for the errors in data were:

-lack of standardization of definitions or unclear definitions for data elements and measures of performance

-the requirement to transfer data from one document to another

-poor work methods or procedures

-failure of those generating and processing data to understand how they are affected by the use of the data

-inadequate training in coding of data elements

-inadequate validation and error detection instructions in computer software

-lack of internal controls to insure data accuracy

-failure to use accuracy of generated data as an element in performance evaluation

Just as quality assurance provisions are incorporated in the process of producing goods, quality assurance should also be an integral part of the system of data generation, processing and analysis.

## ACTION REQUIRED

Essential actions needed to improve the quality of products in data form include:

-Standardizing definitions for data elements and measures of performance. Data elements and measures such as receipt of a purchase request or procurement work directive, award of that requirement, and procurement administrative lead time should be assigned standard definitions at the highest level at which they are commonly used. Standardization would make comparisons of work done by similar organizations at different agencies or departments easier, more accurate and more meaningful.

-Communicating standardized definitions to all involved in the process of data generation, processing and analysis--from clerks to contract specialists to analysts to managers. Just publishing standardized definitions is not enough. Everyone in the chain of command needs to be aware of and thoroughly understand these definitions. The USACSA analysts' experience showed that even the term "receipt of a purchase request" was subject to different interpretations. Definitions must be specific as to what to count, when to count it and the source of the data. Each term of a definition must also have a standard meaning.

-Appropriate training at all levels to educate personnel about the use of data and to instill the importance of data accuracy. People need to know what is being done with the data they generate and now it affects them and their organization. For example, staffing standards use workload data to determine the number of people required to accomplish the assigned mission. People should know what comprises that workload data. They should also understand the effect of of inaccurate data on the office.

-Applying internal controls which provide assurance of data quality. Whether it is a review by someone other than the originator of the data, checks and balances included in computer software or statistical sampling on a regular basis, internal controls are needed to provide assurance of data quality. Carefully crafted controls can save hours and dollars that would otherwise be devoted to searching out and correcting erroneous data. Internal controls can also prevent spending time and money implementing decisions based on faulty information.

-Automating operations to the maximum extent practicable, with emphasis on source data automation and insuring that accurate management data are available from the automated system as a by-product of normal processing. The greatest practicable use of source data automation will reduce opportunities for errors that result from misreading input or transposing figures. In addition, during computer systems design, care should be taken to incorporate sufficient validation and error detection techniques. A few extra hours of thinking and planning when developing functional specifications can prevent many of the errors currently existing in automated data bases by catching at the point of entry the most common errors and requiring correction of the data before it is accepted by the system. For example, software can include checks which prevent acceptance of awards with dates earlier than the date of receipt of the purchase request and acceptance of awards dated prior to opening/closing of the solicitation. Conflicting data elements relating to the classification of an action as a sealed bid or negotiated procurement can be identified and required to be resolved before input is accepted for the file. Incompatible combinations of codes can be identified and rejected before entry. Posting of award information to the wrong purchase request record and accidental cancellation of purchase requests or awards because of an error in input of the control number can be greatly minimized by requiring a match of some additional fields of information such as stock number and vendor before taking the requested action. In addition to taking these actions to improve accuracy, operating procedures should be designed to capture the required management data in the normal course of operations.

-Incorporating accuracy of records as an element of performance standards and giving systematic feedback on performance to all of those involved with data generation, processing and analysis. When the accuracy of records under the control of a manager and his people become part of the performance evaluation system, the quality of data will improve. When accuracy of data becomes important enough to measure, accurate recording and reporting of data will be important enough to do consistently. Systematic feedback is crucial because people need to know how they are doing on a regular basis. It is important to communicate not only the assessment of their performance but also their importance to the successful accomplishment of the work done by the organization. No matter what the level of the pay scale for the individuals who are responsible for original data entry, their contribution is most important. If they do their job right then those further up the line do not have to spend time investigating and correcting erroneous data.

## CONCLUSIONS AND SUMMARY

The experience of USACSA analysts on recent projects and data available from other services indicate that data bases for contracting contain significant amounts of inaccurate information and need improvement. Not only day-to-day management but also accurate assessment of trends, productivity and the success of procurement reforms depends on the quality of information available to analysts and managers. Increasing demands and slimmer budgets are factors which should spur action to make a quality assurance program for management data a standard practice. Accurate information is the key to improving service to the customer and making the right decisions during the lean years DoD is facing.

Essential actions needed to improve the quality of data include: standardizing definitions for data elements and measures of performance, communicating standardized definitions throughout the chain, training, applying internal controls, automating operations, incorporating accuracy of records as an element of performance standards and giving systematic feedback on performance.

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# MANAGEMENT OF COMPLEX SYSTEMS

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## ABSTRACT

This paper reports on the conduct and results of 8 workshops held between December 1987 and June 1989. All the workshops examined the Defense Acquisition Process, and explored mechanisms for its improvement. Nominal Group Technique and Interpretive Modeling methodologies were used to provide a disciplined structure for the work. Included here are:

- summaries of workshops findings and recommendations, (the data base);

- insights concerning DoD's complex acquisition process and how it might be improved; and

- how workshop results might be used to study complex processes in general.

## BACKGROUND

Each year, the Defense Systems Management College (DSMC) usually offers two one week courses for senior Technical Managers: The Technical Managers Advanced Workshop (TMAW). TMAW provides a means for senior managers to focus on particularly difficult management problems and develop suggested solutions.

Beginning in November of 1987 and continuing until June 1989, a series of 9 workshops examined the Defense Acquisition System in detail. Five workshops were directed by the Undersecretary of Defense (Acquisition) [USD(A)]. The genesis for those workshops was a November 1987 directive to USD(A) from the Deputy Secretary of Defense to conduct a Secretarial Performance Review of Smart Munitions Programs. The review, held on 12 May 1988, concluded that there appeared to be significant difficulties in meeting program objectives. USD(A) tasked the Chairman of the Defense Acquisition Board's Convent-ional Systems Committee (DAB-CSC) to develop a set of "aggressive changes to the acquisition process which [would] achieve a more effective Smart Munitions Program". His memorandum to Military Department Service Acquisition Executives (SAE's) said:

"I have tasked the Chairman of the Conventional Systems committee to report back to me with recommendations for aggressive changes in the smart munitions acquisition process to insure a more effective program. We must take action to identify those factors which inhibit us from meeting our...objectives...and develop realistic solutions for near-term implementation and program improvement. To this end, a series of workshops will be conducted through the Defense Systems Management College (DSMC) and will require participation by selected Program Managers, Deputy Program Managers, and contractor Program Managers. These three-day workshops will present a structured, disciplined, and methodical approach to problem solving."

Four workshops were held from 1 August to 29 September 1988. On 11 October 1988, a Task Force met to review and consolidate workshop insights and recommendations. The DAB met on 8 December 1988 and adopted all the Task Force recommendations.

A special TMAW was (held from 5-9 December 1988) to assist OSD by examining potential consequences if the DAB adopted the recommendations.

In March 1989, USD(A) directed his Principal Deputy to implement the Task Force recommendations - and to continue to search out feasible improvements to the Defense Acquisition Program. But before any significant actions were taken, the Undersecretary and his Principal Deputy resigned their posts and a significant period ensued during which neither post was filled. Also during that period, the Congress passed substantive legislation which materially affected the Defense Acquisition System and those who work within it. Because of changes to both legislation and regulation, 2 TMAW's held in May and June of 1989 reexamined currently held perceptions of inhibitors to meeting development program objectives and the probable consequences of implementing the DAB approved actions.

Table 1 provides a time line of events which occurred throughout the period from October 1987 through June 1989 that bear on work reported here. Table 1 includes dates of each event; indicates the event; and if the event was a workshop, shows questions the workshop participants explored.

TABLE 1
SIGNIFICANT EVENTS

| DATE | EVENT |
|---|---|
| 10/87 | USD(A) DIRECTED TO CONDUCT REVIEW OF SMART MUNITIONS PROGRAMS |
| 11/87 | TMAW88-1: DESCRIBE ACQUISITION PROCESS AND INITIATIVES TO IMPROVE IT |
| 05/88 | SECRETARIAL PERFORMANCE REVIEW: SMART MUNMUNITIONS WORKSHOPS DIRECTED |
| 08/88 THRU 09/88 | SMART MUNITIONS ACQUISITIONS WORKSHOP: ISSUES - CRITICAL FACTORS INHIBITING MEETING COST AND SCHEDULE OBJECTIVES & OPTIONS WHICH IF IMPLEMENTED WILL IMPROVE PROGRAM MANAGER PERFORMANCE |
| 10/88 | SMART MUNITIONS TASK FORCE WORKSHOP: REVIEW & ORGANIZE WORKSHOP GENERATED OPTIONS; ASSIGN RESPONSIBILITIES TO GROUPS IN THE ACQUISITION |
| 12/88 | TMAW89-1: CONSEQUENCES OF SMART MUNITIONS RECOMMENDATIONS |
| 12/88 | DAB MEETING: ADOPT SMART MUNITIONS TASK FORCE RECOMMENDATIONS |
| 03/89 | USD(A) ASKS PRINCIPAL DEPUTY TO IMPLEMENT DAB DECISION |
| 05/89 | TMAW 89-3S: DESCRIBE ACQUISITION PROCESS & INITIATIVES TO IMPROVE IT |
| 06/89 | TMAW 89-2: CONSEQUENCES OF IMPLEMENTING DAB ACTIONS" |

## THE DATA BASE

### 1. Methodology

The Defense acquisition process is very complex.

- It requires the integration of knowledge from a variety of disciplines and perspectives from the private, military, and public sectors of society.

- Weapon developments generally are undertaken especially to obtain "quantum improvements" to "existing" war fighting capability.

- Development activities take place under sets of laws and regulations severely restricting permitted actions and methodologies.

- Protection and promotion of the "public interest" may give rise to possibe counterproductive practices.

- While commercial products can set narrow product technical and support complexity limits, military products may generate much more complex requirements if they are to provide improved capabilities over a wide range of uses.

- Use of standard commercial development engineering methods may be severely limited by the need accurately to estimate system cost when the system is still unstructured and known only in general terms.

- The development process is characterized by rapid changes in the basic elements constituent to any ordered process - requirements, technology, resources, and public perception.

As might be expected, managing such complex processes requires special skills.

A major goal of Professors John Warfield, Alexander Christakis, and David Keever has been to gain understanding of complex problems and to develop useful methodology to solve them; working first at the University of Virginia, and later at George Mason University's Center for Interactive Management (GMU CIM). In 1984, Christakis and Keever published "An Overview of Interactive Maqnagement" which described the methodology, and the kinds of problems it can address. That more complete methodological discussion of generating structural understanding of complex problems appears in Appendix I-3 of the Smart Munitions Final Report. Christakis and Keever applied Interactive Management techniques to many different kinds of complex issues. Defense acquisition is one example. GMU-CIM provided a structure for TMAW 88-1, all of the Smart Munitions workshops, the Task Force Workshop, TMAW 89-1, and TMAW 89-2.

Two proceedures are the basis for the process: Nominal Group Technique (NGT), and Interpretive Structural Modeling (ISM). Figure 1 presents a time line of the steps involved in generating group perceptions of complex problems (NGT). Relationships between groups of ideas were determined using the process described by Figure 2. Referring first to Figure 1: during all workshops

a. Problem or issue was "The Defense Acquisition Process";
b. Groups were the various TMAW and Smart Munitions participants;
c. Trigger questions were as shown in Table 1 above;
d. Ideas were provided and are reported as "data";
e. Facilitators during this work were Christakis, Keever, Margaret Fiori (a Research Associate member of the GMU CIM), Gregory Wierzbicki (Provost of the Defense Systems Management College), and me.

Except for the Smart Munitions Task Force, (where the ideas that were used in discussion were those generated by the previous Smart Munitions workshops), ideas discussed were those of the group in session. For the Task Force Workshop, ideas discussed were

FIGURE 1

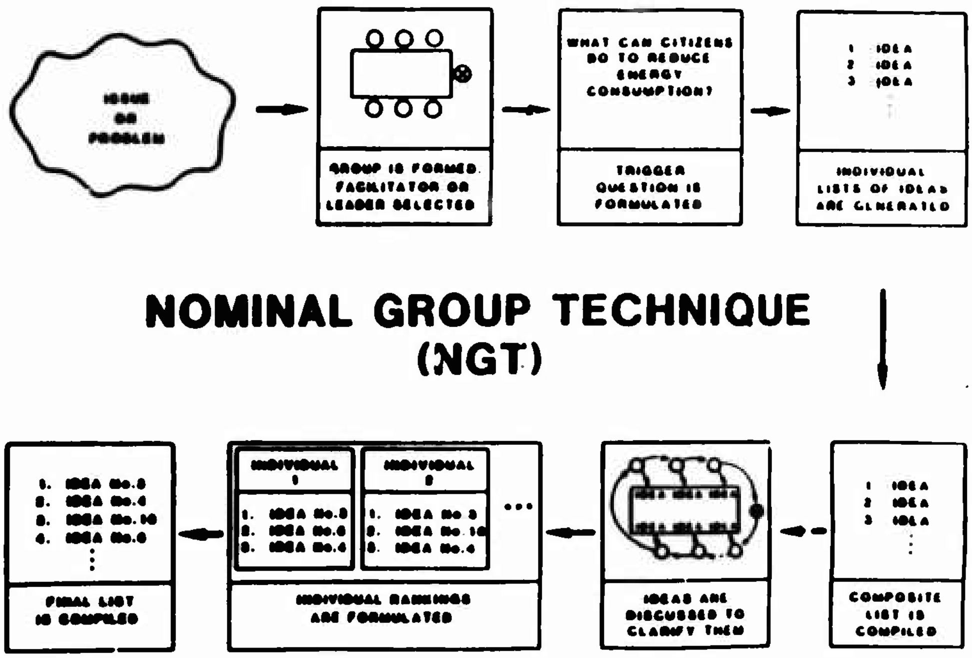
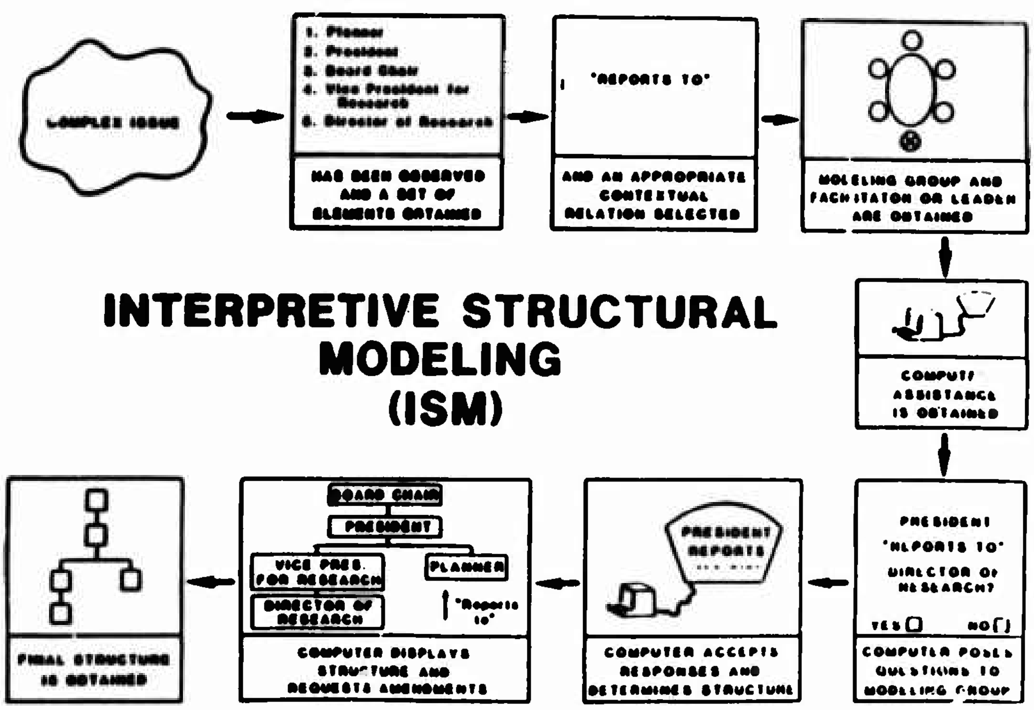



FIGURE 2



"clarified" by members of the groups which initially generated them.

2. The Data

A. TMAW 88-1

As indicated in Table 1, TMAW 88-1 considered two questions: "What are descriptors of the acquisition work we do?"; and "What initiatives will foster/improve the work we do in acquision?"

The first question provided some basis for analyzing data from the 4 Smart Munitions Acquisition workshops. It provided a group perception of Program and Technical Management functions. The second question provided some actions which workshop participants perceived could be taken to improve acquisition performance.

(1) What Managers Do - Nominal Group Technique (NGT) was used to generate 74 statements. Participants then determined rankings for the 74 statements. 6 of the statements were felt to be most important. Those 6 statements were used as primary cues to generate 6 functional groups which contained all 74 statements. Interpretive Structural Modeling (ISM) was then used to determine the order of difficulty of the six functional groups.

Table 2 presents the total number of statements within the group's total perceptionof the problem, and lists those statements felt by the group to be most important (in order of importance).

TABLE 2
TMAW 88-1 EVENT SEQUENCE AND STRUCTURE

| PERCEPTION OF WHAT PROGRAM MANAGERS DO |
|---|
| 1st Step Generate a Total Problem Perception<br>NGT GENERATION OF 74 FUNCTIONAL STATEMENTS |
| 2nd Step Select Most Important Elements<br>SELECT THE 6 MOST IMPORTANT STATEMENTS |
| 1. Manage change<br>2. Help assure needs are met<br>3. Manage 7 step system acquisition process<br>4. Provide schedules<br>5. Manage to deliver quality within schedule and budget and at a profit<br>6. Assess and manage risk |

Table 3 identities 6 functional groupings which contain all 72 problem statements. The list is in the order of perceived importance with the two groups thought to be of equal importance are shown as groups 2A, and 2B. The number of statements included in each group is also shown.

(2) What can be done to help improve Program Manager performance - Having generated the dimensions of the problem, the group was asked to generate ideas which might improve program manager performance. 80 initiatives were proposed. 7 statements were selected which described the most important ideas. Table 4 summarizes the group perception of the most important initiatives within the 80 developed by the participants.

TABLE 3
TMAW 88-1 EVENT SEQUENCE AND STRUCTURE

| Step 3 Determine Functional Groupings<br>FUNCTIONAL CATEGORIES (INCLUDES ALL 72 STATEMENTS IN ORDER OF IMPORTANCE | | |
|---|---|---|
| 1. | LEADERSHIP | (20) |
| 2A. | REQUIREMENTS DEFINITION AND TECHNICAL PROPOSALS | (12) |
| 2B. | RESOURCING (EXTERNAL FOCUS) | (16) |
| 3 | PROGRAM EXECUTION | (14) |
| 4 | PLAN AND PROGRAM (INTERNAL FOCUS) | (11) |
| 5 | FOREIGN MILITARY SALES | ( 1) |

TABLE 4
TMAW 88-1 MOST IMPORTANT INITIATIVES

| INITIATIVES TO IMPROVE PROGRAM MANAGERS PERFORMANCE |
|---|
| Generate a Total Solution Space<br>NGT GENERATION OF 80 FUNCTIONAL STATEMENTS |
| Select Most Important Initiatives<br>SELECT THE 7 MOST IMPORTANT STATEMENTS |
| 1. Give PM authority approprate to responsibility<br>2. Rationalize our organizational structure<br>3. Stabilize program resourcing<br>4. Have a value added gate for new legislation<br>5. Simplify acquisition rules<br>6. Prioritize programs, cut the ones you can't afford<br>7. Improve quality of threat projection |

ISM techniques provided the structural map shown as Figure 3. Figure 3 indicates two critical junctions in the solution space structure: "create a more capable" work force, and, "must stabilize program resources".

Insights gained in TMAW 88-1 about tasks of program management and initiatives which might improve the acquisition process, provided the basis for structuring Smart Munitions Acquisition Improvement Program (SMAIP) workshops.

B. SMART MUNITIONS ACQUISITION IMPROVEMENT WORKSHOPS

The four Smart Munitions Acquisition Improvement Workshops provided a broad range of suggested acquisition improvements. Participants responded to the same trigger questions asked of TMAW 88-1 participants. The four workshops generated a total of 285 perceived inhibitors; and 265 suggested improvement initiatives. Table 5 lists inhibitors the participants felt to be most important, Table 6 lists the iniatives.

Following TMAW 88-1 procedures, participants used the statements in Table 6 to group all statements under major headings. Those headings, with the number of initiatives they include, appear in Table 7. During the grouping process, some statements were combined with others. Table 7 indicates original numbers of statements produced and the number which survived the grouping.

FIGURE 3

**SUPPORT STRUCTURE OF INITIATIVES TO IMPROVE TECHNICAL MANAGER ACQUISITION WORK**

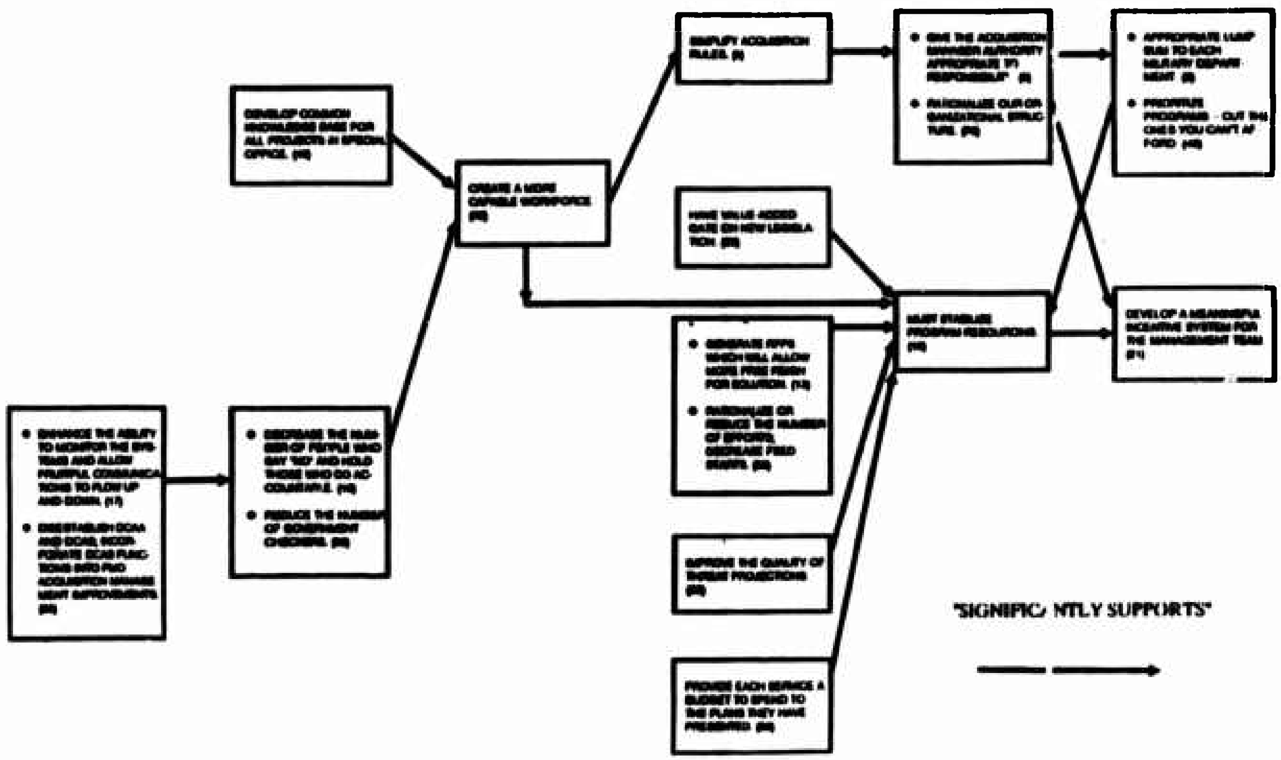



TABLE 5
SMART MUNITIONS ACQUISITION IMPROVEMENT PROGRAM
CONSOLIDATED LIST OF INHIBITORS TO MEETING COST AND SCHEDULE OBJECTIVES

TOTAL OF SMAIP INHIBITOR STATEMENTS = 285

AIR-TO-SURFACE: TOTAL 83
1. Dilution of Program Managers authority
2. Year-to-year instabilities to budget and procurement quantities
3. Changing requirements
4. Unrealistic program plans/schedules and associated funding profiles
5. Micro-management at all levels of oversight

SURFACE-TO-SURFACE: TOTAL 78
1. Inability to lock in the requirements
2. Lack of program funding stabilicy
3. Too many inhibitors outside the control of the Program Manager
4. Government Program Managers cannot control programs
5. Lack of adequate engineering discipline during all program phases
6. Lack of adequate Program Manager staff and motivating factors to maintain them

TABLE 5 (CONTINUED)
SMART MUNITIONS ACQUISITION IMPROVEMENT PROGRAM
CONSOLIDATED LIST OF INHIBITORS TO MEETING COST AND SCHEDULE OBJECTIVES

SURFACE-TO-AIR/ASW: TOTAL 58
1. Lack of regulation and historical approach cleansing
2. Lack of consistent budget for planning purpose
3. Changes in policy and specifications
4. Existance of extensive special interest bureaucracy within the acquisition infrastructure

AIR-TO-AIR/ASW: TOTAL 66
1. Poorly defined and changing technical requirements
2. Misestimation of technical difficulties
3. Lack of Program Managers flexibility (agility) to deal with change
4. Instability of DoD and Congressional support for programs
5. Annual production budget fluctuations leading to bath tubs and gaps
6. Illogical competition

TABLE 6
SMART MUNITIONS ACQUISITION IMPROVEMENT PROGRAM
CONSOLIDATED LISTING OF INITIATIVES TO MEET COST AND SCHEDULE OBJECTIVES

| TOTAL OF SMAIP INITIATIVE STATEMENTS = 265 |
|---|
| AIR-TO-SURFACE: TOTAL 83 |
| 1. Establish policy to strengthen acquisition functions within the services and DoD |
| 2. Baseline and commit to long term financing |
| 3. Streamline Program Managers reporting to service acquisition executive |
| 4. Authorize Program Managers funding flexibility and real-time tradeoffs |
| SURFACE-TO-SURFACE: TOTAL 67 |
| 1. Establish P3I programs early in FSD to address desired requirements (high risk) outside the scope of baseline program |
| 2. Establish funding requirements to match program requirements and maintain stability/ |
| 3. Assure Program Manager authority is commensurate with responsibility |
| 4. Generate a delegation of authority statement for each Program Manager; and sign it by the Program Manager, the acquisition executive and the supporting organization chief |
| 5. Make program management a career track within the services |
| SURFACE-TO-AIR/ASW: TOTAL 57 |
| 1. Improve Program Manager and program management staff training and experience to develop a professional acquisition corps |
| 2. Provide Program Manager authority over supporting agencies |
| 3. Encourage Congress, OSD, and the services to establish program budgets for phases |
| 4. Implement a plan for selected programs that will allow the Program Manager to select/challenge the policies and regulations applying to that program |
| 5. Establish a success measurement plan (who, what, how) |
| AIR-TO-AIR/ASW: TOTAL 58 |
| 1. Establish approval authority, responsibility, and resources lower in the organization, i.e., into the services |
| 2. Stabilize requirements and budgets |
| 3. Give program manager more authority commensurate with his responsibility over the destiny of the program |
| 4. Establish high level controls to approve initiation of and establish ment of bounds to audit activities |
| 5. Require ROI considerations in decisions to compete (e.g. methodology) |

Tables 3 through 7 demonstrate the breadth of perspective about both inhibitors to conducting acquisition programs on time and within budget, and initiatives which might improve the situation.

TABLE 7
SMART MUNITIONS ACQUISITION IMPROVEMENT PROGRAM
CONSOLIDATED LISTING OF MAJOR GROUPING OF INITIATIVES WHICH HELP MEET COST AND SCHEDULE OBJECTIVES

| | |
|---|---|
| AIR-TO-SURFACE: 83 --> 78 | |
| 1. ACQUISITION EXECUTIVE RESPONSIBILITY | 23 |
| 2. LAWS | 6 |
| 3. INDEPENDENT TEST AND EVALUATION | 5 |
| 4. PROGRAM STABILITY | 13 |
| 5. PROGRAM MANAGER AUTHORITY | 6 |
| 6. PROGRAM FLEXIBILITY | 10 |
| 7. INNOVATION | 13 |
| 8. COSTING IMPROVEMENTS | 4 |
| 9. TEAMWORK | 2 |
| SURFACE-TO-SURFACE: 67 --> 65 | |
| 1. POLICIES | 10 |
| 2. USER INVOLVEMENT | 7 |
| 3. STRATEGIC PLAN | 8 |
| 4. PROGRAMMATICS | 6 |
| 5. PROGRAM MANAGER AUTHORITY | 8 |
| 6. ORGANIZATIOAL STRUCTURE | 6 |
| 7. BASELINE PROGRAM | 13 |
| 8. QUALIFICATION AND TRAINING | 6 |
| 9. PARTICIPATIVE PROBLEM SOLVING | 1 |
| SURFACE-TO-AIR/ASW: 57 --> 53 | |
| 1. MISSION AND PROGRAM DEFINITION | 6 |
| 2. CONTROL PROCEDURES | 11 |
| 3. BUDGET STABILITY | 5 |
| 4. OVERSIGHT | 9 |
| 5. AUTHORITY | 9 |
| 6. STAFFING | 10 |
| 7. JUSTIFICATION | 2 |
| 8. GOVERNMENT ROLE | 1 |
| AIR-TO-AIR/ASW: 58 --> 52 | |
| 1. GLOBAL CONCERNS | 3 |
| 2. PROGRAM MANAGER AUTHORITY | 10 |
| 3. STAFFING | 5 |
| 4. PROGRAM STABILITY | 11 |
| 5. PROGRAM PRIORITIZATION | 2 |
| 6. REVIEWS AND AUDITS | 7 |
| 7. ACCOUNTABILITY | 6 |
| 8. TECHNOLOGY BASE | 1 |
| 9. TOOLS | 1 |

### C. SMART MUNITIONS ACQUISITION IMPROVEMENT TASK FORCE

The task force function was to review the workshop output, consolidate workshop ideas, and develop an implementable set of action projects. To help begin that work the DoD Program Officer, Tony Melita, met with me to devise a list of "Project Areas" which we thought could provide headings for grouping all workshop initiatives. The Task Force adopted them and used them in their review of 248 surviving initiatives developed by the workshops. Workshop product integrity was preserved by having workshop representatives at task force deliberations to answer questions about the "meaning" or "context" of an inhibitor.

The task force focused on three "Project Areas" which contained almost half of the initiatives. Table 8 lists each "Project Area", the number of SMAIP workshop initiatives in each of them, and the number of initiatives created by the task force to represent workshop ideas.

TABLE 8
SMART MUNITIONS TASK FORCE PROJECTS AND NUMBER OF INITIATIVES INCLUDED

| WORK PROJECT TITLE | INCLUDED WORKSHOP | INITIATIVES TASK FORCE |
|---|---|---|
| PROGRAM MANAGER AUTHORITY | 60 | 14 |
| BUDGETARY CONSIDERATIONS | 40 | 6 |
| REQUIREMENTS | 21 | 9 |
| TESTING | -- | -- |
| PROGRAMMATICS | | |
| PREPLANNED PRODUCT IMPROVEMENTS | 127 | |
| PROGRAM MANAGER TRAINING & CAREERS | WORKSHOP | |
| PROGRAM CONTROL | | |
| MEASURES OF SUCCESS | INITIATIVES | |
| SCOPE OF GOVERNMENT ACTIVITY | | |
| AUDIT ACTIVITIES | STILL TO BE | |
| SPECIFICATION TAILORING | | |
| PROGRAM STABILITY | ASSIGNED | |
| STAFFING | | |
| OTHER CONCERNS | - | - |

The Chairman of the Defense Acquisition Board's Conventional Systems Committee (DAM-CSC) decided to recommend 8 initiatives to the DAB for implementation. Four fell within the Program Manager Authority Work Program; three within the Budgetary Considerations Work Program; and one within the Requirements Work Program.

(1) Program Manager Authority Initiatives

(a) DEMAND THE SAE TO EXERT STRONG MANAGEMENT CONTROL OVER ACQUISITION ORGANIZATION
Issue: Existance of adversarial relationships ill-defined organizational lines of authority. Too many layers/special interests.
Action: DAE should meet with the SAEs and direct them to set up the PM-PEO-SAE-DAE structure. No layers between. Rating reflects structure. Notify all others to support role.

(b) ISSUE ALL ACQUISITION DOCUMENTATION FROM DAE/SAE DIRECTLY TO PEOs/PMs.
Issue: Insufficient DAE/SAE involvement in acquisition documentation and an inordinate amount of time for distibution/implementation.
Action: SECDEF to direct that all changes in acquisition documentation be concurred in/ issued by the DAE/SAE and implementation be directed from that point.

(c) IMPLEMENT A PROCESS THAT ALLOWS THE PM TO CHALLENGE POLICY, DIRECTIVES REQUIRED BUT NOT IN THE BEST INTERESTS OF HIS PROGRAM.
Issue: Lack of PM flexibility to challenge policy/directives/regulations etc.
Action: OSD/Services evaluate the "Model Installations Program" and "Pilot Contracting Program". Propose modified plan to CSC for review. Report back to the CSC by 24 Feb 89 with findings.

(d) SAE RESOLVES PROGRAM COST/SCHEDULE IMPACT IN RESPONSE TO ACQUISITION CHANGES AT TIME OF IMPLEMENTATION
Issue: Lack of up-front understanding of cost/schedule impact of acquisition change.
Action: Augment DoD 5000.1 to require an implementation plan for all acquisition changes imposed on a program after program baseline/initiation. Plan should identify cost and schedule impact, tradeoffs, resource requirements, etc.

(2) Budgetary Consideration Initiatives

(a) ENHANCE EXISTING COST/SCHEDULE/PERFORMANCE ESTIMATING METHODOLOGIES TO SUPPORT PROGRAM/BUDGET DEVELOPMENT.
Issue: Inadequate R&D cost estimating methods/models used to forecast todays's complex munitions systems cost/schedule.
Action: The cost analysis improvement group (CAIG), with support from services and industry cost estimators should identify existing methodologies and evaluate for adequacy. If deficient, provide a plan for improvement. Report back to the CSC by 24 Feb 89 with findings.

(b) REQUIRE SOME LEVEL OF RISK FUNDING ON PROGRAMS AT A LEVEL COMMENSURATE WITH THE DEVELOPMENT RISK.
Issue: Insufficient/non-existent management reserves to deal with risk.
Action: Services review AR 70-6 (TRACE) for adequacy. If deficient, provide recommendations for improvement. Report back to CSC by 24 Feb 89 with findings.

(c) REQUIRE ALL COMPTROLLER ADJUSTMENTS TO PROGRAM BUDGETS ARE COORDINATED IN ADVANCE WITH DAE/SAE AND CONSIDERPMs ASSESSMENT OF COST/SCHEDULE/PERFORMANCE IMPACTS.
Issue: Unilateral removal/taxing of program funding by DOD/Service Comptrollers.
Action: OSD prepare a DoD policy statement and implementing directive for realigning OSD and Service Comptroller procedures to accomodate acquisition executive approval on all proposed funding adjustments to smart munitions programs. USD(A) meet with ASD(C) during transition period and discuss division of labor and procedures.

(3) Requirements Initiatives

(a) DEFINE CRITICAL PROGRAM REQUIREMENTS AND MAKE ALL OTHER REQUIREMENTS APPLICABLE AS A FUNCTION OF COST/SCHEDULE/BENEFIT.
Issue: Lack of prioritization/understanding of system requirements.
Action: Services issue policy statement and implementing directive to make draft RFPs mandatory. Conduct draft RFP industry conferences and pre-proposal conferences to facilitate discussion/understanding of the requirements. SAEs report to DAE by 27 Jan 89 with status.

All recommendations presented to the DAB on 8 December 1988 were approved by the DAB and their implementation directed by USD(A).

D. TMAW 89-1

TMAW 89-1 was held specifically to develop some forwarning about what might happen if the DAB approved the recommendations made on 8 December; (in fact, the results of TMAW 89-1 were briefed to Tony Melita the day prior to his DAB briefing). The question "What are anticipated consequences from the implementation of the DAB package?" was considered. Participants were asked to consider all 8 recommendations and make their comments on any or all of them. 69 potential consequences were developed. The most important consequences, by category, were:

(1) Program Managers' Authority: (20 consequence statements developed)
  (a) Increased adversarial relationships as players and organizations are reduced.
  (b) SAEs will have to create a large, knowledgeable staff to handle his new responsibilities.
  (c) A strengthened DAE/SAE role.
  (d) Increase PM's ability to match resources and requirements.

(2) Budgetary Considerations: (31 consequence statements developed)
  (a) Identification of risk funding as "Risk Funding" gives visibility for funding reduction.
  (b) Will provide more stable program.
  (c) Contribute to Prioritization of defense requirements.
  (d) May cause government to re-examine PPBS process for improvement and create a team approach to solving budget/program issues.
  (e) Could increase Congressional and Public trust and respect for defense budget and procurement system and lead to stronger support of defense programs.
  (f) Risk funding would be interpreted as a slush fund by Congress and taken away.

(3) Requirements: (18 consequence statements developed)
  (a) Appropriate use of draft RFPs will further slow down the contracting process.
  (b) Increase Congressional confidence in the integrity of the requirements process in defense systems acquisition.
  (c) Implementation action may not resolve the entire issue/statement.

Once again, participants were asked to group all statements within "consequence categories", and to determine the relative importance of each category. Table 9 lists the categories and the number of consequences in each of them. Several categories were considered to be of equal relative strength. That relationship is preserved by using upper case letters after the number to indicate strength level (e.g., 2A, 2B, etc).

In constructing the consequence categories, some potential consequences were felt to apply to more than one category. For that reason, the numbers within all consequence categories in Table 9 total to 85 rather than 69, the number of statements developed by the participants.

TABLE 9
TMAW 89-1 CONSEQUENCE CATEGORIES WHICH INCLUDE ALL 69 STATEMENTS* LISTED IN ORDER OF IMPORTANCE

| | | |
|---|---|---|
| 1 | DOD/SERVICE ORGANIZATIONAL IMPACT | (13) |
| 2 | CREDIBILITY | (10) |
| 3A | PM IMPACT | (12) |
| 3B | USER IMPACT | ( 8) |
| 4A | IMPACTS OF RISK FUNDING | (12) |
| 4B | DRAFT RFPS | (11) |
| 4C | BUDGETING | ( 8) |
| 5 | CONTRACTOR IMPACT | ( 7) |
| 6 | BUSINESS AS USUAL | ( 4) |

* Some consequences applied to more than one consequence category.

The group developed more negative than positive consequences. Their consensus opinions advised great care in thinking through all potential ramifications of change well in advance of their institutionalization.

E. TMAW 89-3S

TMAW 89-3S was held at the University of Arizona Interactive Management Center during the week of 22 April 1989. Much had happened during the period between December 1987 and April 1989: Key Defense personnel changes had occurred; there was considerable public discussion about initiatives begun by USD(A) in total quality management, streamlining, competition, and concurrent engineering; and 18 months had passed since the first examination of characteristics of the acquisition process in TMAW 88-1. It was decided that re-examination of the question "What are the inhibitors to your meeting cost and schedule objectives?" would provide another data point about the changing dimensions of the problem.

The group developed 65 inhibitors to program managers meeting cost and schedule objectives. Table 10 presents the 7 inhibitors thought most important.

TABLE 10
TMAW 89-3S MOST IMPORTANT INHIBITORS

| NGT GENERATION OF 65 FUNCTIONAL STATEMENTS |
|---|
| SELECTED THE 7 MOST IMPORTANT STATEMENTS |
| 1 Acquisition process forces unrealistic cost and schedule submissions |
| 2 Yearly budgeting/funding prevents stability |
| 3 Lack of discipline by the Services i requirements determination |
| 4 Attracting and keeping top personnel in Government |
| 5 Unwillingness to relieve established requirements |
| 6 Government-Industry coordination too late for cost/requirement options |
| 7 Failure to promote and support acquisition streamlining |

Again, clusters were developed and the inhibitors grouped within them. Table 11 presents the cluster groups. While most inhibitor statements easily fit within one of the 6 focused statements, a group of 8 statements were sufficiently different to warrant their grouping into a "miscellaneous" cluster.

TABLE 11
TMAW 89-3S CLUSTER CATEGORIES WHICH INCLUDE ALL 65 STATEMENTS LISTED IN ORDER OF IMPORTANCE

| | |
|---|---|
| UNREALISTIC COST AND SCHEDULE SUBMISSION | 12 |
| INAPPROPRIATE REQUIREMENTS DETERMINATION | 14 |
| LACK OF EFFECTIVE LEADERSHIP | 13 |
| EXCESSIVE AND PERJORATIVE OVERSIGHT SYSTEM | 7 |
| INDUSTRIAL BASE EROSION DUE TO LACK OF INVESTMENT INCENTIVES | 6 |
| LACK OF APPROPRIATE DESIGN PROCESS AND ENVIRONMENT | 5 |
| UNASSIGNED | 8 |

An alternative methodology was used to determine relationships between cluster groupings. The question was asked, "Does the inhibitor set in Cluster A exacerbate the problems of inhibitor set B?". The result of asking that question for all possible comparison permutations appears as Table 12.

TABLE 12
TMAW 89-3S STRUCTURAL MAP OF INHIBITOR CLUSTERS IN MATRIX FORMAT

| DOES CLUSTER # | --->EXACERBATE THE PROBLEMS OF---->CLUSTER # | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| 1 | CURRENT ACQUISITION PROCESS FORCES UNREALISTIC COST AND SCHEDULE REQUIREMENTS | | Y | N | N | Y | N |
| 2 | INAPPROPRIATE REQUIREMENTS DETERMINATION | Y | | N | Y | Y | N |
| 3 | LACK OF EFFECTIVE LEADERSHIP | Y | Y | | Y | Y | N |
| 4 | EXCESSIVE AND PERJORATIVE OVERSIGHT SYSTEM | Y | Y | Y | | Y | N |
| 5 | INDUSTRIAL BASE EROSION DUE TO LACK OF INVESTMENT INCEN- | N | N | N | N | | N |
| 6 | LACK OF APPROPRIATE DESIGN PROCESS AND ENVIRONMENT | Y | Y | N | = | Y | |

Table 12 reveals that in the groups opinion:

- Clusters 3 (Lack of Effective Leadership) and 4 (Excessive and perjorative oversight system) exacerbated problems described in all other clusters except Cluster 6 (Lack of appropriate design process and environment).

- Cluster 6 (Lack of appropriate design process and environment) exacerbated problems described in Clusters 2 (Inappropriate requirements determination) and 5 (Industrial base erosion due to lack of investment incentives)

- Cluster 2 (Inappropriate requirements determination) exacerbated problems described in Clusters 1 (Current acquisition process forces unrealistic cost and schedule requirements), 4 (Excessive and perjorative Oversight system) and 5 (Industrial Base erosion)

In addition, Table 12 indictes several instances of mutual exacerbation: e.g., Cluster 2 exacerbates problems in Cluster 1 and Cluster 1 exacerbates problems in Cluster 2.

The results of THAW 89-3s indicated that there had been few changes in participants perceptions about the inhibitors to program manager performance during the period between November 1987 and April 1989.

The Arizona facilities made it possible to examine initiatives differently. Participants generated 93 initiatives which they felt were options for overcoming inhibitors. Participants were then asked to state how useful each initiative would be in overcoming the problems grouped within each inhibitor cluster. Major linkages developed were:

(1) For cluster #1: Current acquisition process forces unrealistic cost and schedule submissions.
  (a) Develop new cost estimation methodologies.
  (b) Develop approaches to establishing program requirements as early as possible.
  (c) Congress should implement two year authorization and appropriation.
  (d) Provide more realistic contract selection.

(2) For cluster #2: Inappropriate requirements submissions.
  (a) Develop approaches to establishing program requirements as early as possible.
  (b) Requirement specification should occur in properly designed environments*.

(3) For cluster #3: Lack of effective leadership.
  (a) Provide consistent leadership in the acquisition system.
  (b) Provide training on the acquisition process at all levels.

(4) For cluster #4: Excessive and perjorative oversight system.
  (a) Tailor overview and oversight activities to be cost-effective
  (b) Apply appropriate disbarment and suspension penalties.
  (c) Put DCAA under USD(A).
  (d) Encourage self-governance of defense industry through DII principles.
  (e) Promote understanding of how learning depends on freedom to err.

(5) For cluster #5: Industrial base erosion due to lack of investment incentives.
  (a) Modify the tax code with regard to facilities and equipment capitalization
  (b) Acknowledge defense industry characterized by low return on investment.
  (c) Promote export of U.S. defense products to maintain base, improve trade balance, etc.

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* An environment similar to that at the GMU-CIM which provides for group concentration - and surroundings comfortable but not soporific.

(6) For cluster #6: Lack of appropriate design process and environment.
(a) Requirement specifications should occur in properly designed environments.
(b) Require full systems engineering approach throughout programs.
(c) Teach program managers and students the new science of generic design.

The perception of acquisition problems and the solutions proposed in TMAW 89-3S while closely resembling the fundings of TMAW 88-1 and the Smart Munitions Acquisition Program Workshops were somewhat different in thrust and breadth.

F. TMAW 89-2

TMAW 89-2 revisited the issue of predicted consequences from initiating the 8 DAB approved actions. As before, NGT was used to generate consequence statements.

A total of 78 consequence statements were developed. Table 13 lists the 9 headings and the numbers of consequence statements in each of them. TMAW 89-2 provided a different perception of implementation consequences than TMAW 88-2.

TABLE 13
TMAW 89-2 CONSEQUENCE CATEGORIES WHICH INCLUDE ALL 78 STATEMENTS*

| | | |
|---|---|---|
| A | PERSONNEL (HUMAN RESOURCES) | (11) |
| B | PROGRAMMATICS | (20) |
| C | LONG TERM IMPACT (NEUROSIS) | (14) |
| D | MIX OF CLASS I AND II SOLUTIONS | ( 1) |
| E | FUNCTIONARY (OVERSIGHT IMPACTS) | ( 8) |
| F | TRANSITION FROM PM TO MAJCOM LOG MGMT | ( 1) |
| G | DOD/SERVICE BUDGET | (14) |
| H | RESISTANCE OF NAVY & AF TO AR70-6 | ( 4) |
| I | ORGANIZATION | (11) |

* Some consequences applied to more than one consequence category.

## ANALYSIS AND CONCLUSIONS

The data indicate that process perceptions of complex problems change over time. I have defined two dimensions for change: scope and depth of understanding.

a. Scope means the area of ideas within the problem boundary. It measures how many elements are to be contained within a problem definition. When the "scope" of manufacturing processes was defined in terms only of the steps used to turn raw materials into finished products, the range of problems involved within that scope excluded environmental impact, worker health and safety, mandated accounting practices, and many other concerns which today are included within the "scope" of such processes. As the scope of concern broadens, potential interactions between the many additional elements increase exponentially.

Not only does problem scope change over time, but the emphasis on particular elements within the scope also changes. At one point in time, there is great concern over environmental impacts of certain processes, at another, there is less concern for that series of problems than there is for worker health and safety.

To some greater or lesser extent, the scope of a problem and the emphasis placed on elements within it is shaped by external (i.e. Congress) as well as internal (DoD, Services) forces. Concerned persons may or many not understand either the problems they perceive as "real", or the relationships between the process and the problems.

b. Depth of understanding describes the degree to which all elements within the problem scope can be defined; both in terms of their own character-istics, and also in terms of their interactions with all other elements. It is a measure of how well we can predict the effects of changing something in one element and the effect that change will have on all other elements included within the same scope of a problem.

Knowledge of cause and effect (whether derived deterministically or inferred statistically) changes over time. The understanding of interactions between elements of a problem grows (or becomes less certain) as new knowledge is generated.

It does not matter whether new knowledge is "real" or "imagined". To a great extent, group perceptions of reality define what is "known" and shape the courses of action taken to solve problems. What is "known" is what is believed to be known! If there is an error in understanding and that error is unknown, actions taken which include those erroneous relationships deform both the scope and depth of a problem.

Again, "depth" is affected by forces external to the problem.

Within this concept, I think of problems as patterns which constantly vary in size and shape; and change relationships between their components. With such a perception, it becomes crucial to understand the rate at which change can take place, and the dimensions of possible change. In addition, there is no substitute for the ability to predict when an additional element will be added to the scope of a problem and the degree to which its introducition will change scope, depth, and velocity and type of pattern change.

Within that context the difficulties in reaching true "solutions" to problems should be more apparent. It is almost like painting a picture when the

canvas is
- changing in size and shape at varying rates,
- moving in space at changing rates of speed,

colors are
- mixing in unknown and/or unpredictable ways,
- changing their brightness and tone

artists (more than one) are
- each painting on the canvas to their own vision of the scene,
- changing their vision as the pattern of the painting changes!

Such a painting would resemble pictures within a kalidascope: some scenes will be coherent and recognizable; other pictures will be surreal.

Over the course of 18 months, the perception of the problems inherent in our Defense acquisition system has changed; and there have been elements added to the problem in the form of Congressional legislation and internal DoD regulation. Public opinion, working through the media, have caused us to react to focus attention on particular difficulties. In turn, our actions have changed the problem.

Given this perception of complex problems, it is necessary to ask whether there are such things as "solutions"? The desire is to answer "yes"! If there are no possible solutions for complex problems, how are we ever to alleviate the difficulties we perceive and create a better mileu?

In fact, we do deal with problems - and we achieve change in directions we want to go. But those effects are transient because the problem is changing even as we apply the solution, and in fact partly because we apply it! To be effective, our solutions must be

- timely! (an idea whose time has come - applied in time to do some good)
- acceptable! (perceived to be a good solution by those concerned)
- limited! (treating all elements of concern, not necessarily all elements)
- flexible! (have the capacity to accomodate a range of change)

Solutions need constant change too. Perhaps the most favorable situation would find solutions which would themselves adapt in lock step with the changing problem. Solutions having such characteristics may be difficult to institutionalize. The time constant of change for institutions is longer than the time constant of change for problems.

In short: this program of research points to several conclusions:

1. Permanent solutions to complex problems are unlikely.
2. Problem solutions ahould change at (or nearly at) the pace of change in problem perception
3. Institutionalizing problem solutions may tend to create new problems.

Dealing with complexity is a full time occupation - for individuals who have a liking for adventure! Their challenge, and ours, is to understand that treating complex problems requires skills not unlike those of artists, designers, and other such kinds of people. Our educational process needs to help develop such people; and our oversight process needs to provide an environment where they can apply their talents. Neither their task nor ours is simple because we all live in an arena of great complexity - the modern world.

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# PROJECT MANAGEMENT: A STRATEGIC MANAGEMENT PERSPECTIVE

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## ABSTRACT

In the report to the President on Defense Acquisition by the President's Blue Ribbon Commission on Defense Management, April 1986, several successful commercial programs were reviewed to identify management features that could hold promise for effective integration into the Defense Acquisition process. Not so well published have been some of the commercial projects that have had extraordinary problems. The Energy Industry has had its share of problems in the management of design, engineering, and construction projects.

In this paper I will examine the strategic context of projects and how project "failure" is linked to strategic failure in the organization. This examination will be taken primarily from the perspective of several large commercial energy projects and will include a review of the project strategic issues and project stakeholders. In addition, I will conclude by presenting some caveats to guide senior managers in their strategic surveillance of their ongoing projects.

## PROBLEM PROJECTS

In the energy industry there have been some dramatic project shortcomings - projects that have had serious cost and schedule overruns. In most cases these shortcomings were caused in large part by a leadership failure on the part of the corporate managers who failed to provide for the design and implementation of contemporaneous project management techniques and processes by the project teams. The Trans-Alaska Pipeline System (TAPS), the Washington Public Power Supply System (WPPSS), the Shoreham Project, and the Diablo Canyon Project all suffered from the lack of senior management involvement during the planning for and execution of the projects. Inadequate planning, failure to use contemporaneous project management tools and techniques, improper organizational design, indifference and neglect in maintaining ongoing surveillance of the projects, and the lack of a corporate culture to encourage excellence in managing projects all contributed to project failures that resulted in "imprudent and unreasonable" use and loss of corporate resources involving billions of dollars. In all these projects the lack of concern by the senior managers contributed significantly to the creation and propagation of a corporate culture which did not demand excellence and quality in the management of the projects.

The lack of attention of the senior managers, reflecting a pattern of inactivity and of ignorance concerning the problems and threats that buffeted these projects, contributed in a major way to the failures of these projects. It seems clear that these senior managers could have helped to reduce their problems and the associated threats that faced their projects by careful, informed involvement in key matters on a regular basis. This has been done on some nuclear plant projects. For example, in one plant the company's senior managers and board of directors played an active role in the management of the plant. As stated in a letter to the author:

> Our Board of Directors was kept abreast of project activities on a monthly basis. The project issued a monthly report to the Board prior to their meetings. The Project Director was then available at the board meeting to discuss the report. In addition, for several of the critical construction years, the Board held an expanded meeting at the plant site annually. This permitted Board membes to view progress first-hand and permitted additional nuclear topics to be included in the agenda.
>
> The monthly reviews...also served as the regular, integrated review of the project by the project manager/project team. These

reviews included senior management from our engineer/constructor. Senior representation from the reactor manufacturer was also present when appropriate. These meetings focused on performance and progress and highlighted issues significant to management. The reporting of progress and performance was an integrated team effort.

On another type project, the $2.1 billion Milwaukee Water Pollution Abatement Program initiated in 1977, a comprehensive review of the status of the projects in that program is conducted on a monthly basis by the owner senior managers. The program manager is present to explain the program's status and to answer any questions posed by these senior managers. The senior managers, in turn keep the board of commissioners (board of directors) of the Milwaukee Metropolitan Sewerage District informed on a regular basis. This complex program which has had high visibility and has held the attention of many stakeholders during its life cycle is on schedule and close to the original project budget estimates. The continued review by the senior managers and the commissioners is a major reason this project has been successful.

On both these projects the awareness and involvement of the senior managers contributed significantly to success, sending an important message to all the project stakeholders during the course of the project's life cycles.

## THE ROLE OF PROJECTS

Today most organizations can be characterized as being comprised of a "stream of projects." These place demands on organization's resources. At the same time, the health of these projects is a good indication of the strategic success of the enterprise. Since the projects will be in different phases of their life cycle and in one way or another fit into the enterprise's portfolio of strategies, their management is challenging to the key members of the organization. Balancing the satisfaction of the needs of these projects is most demanding, particularly in allocating resources, scheduling workloads, and maintaining surveillance over the planning, organization and control of the projects from the perspective of the strategic management of the entire enterprise. This strategic management rests on two key elements: The responsibility of the senior managers to be aware of the considerations of the enterprise in facilitating the management of the projects, and the development of strategies for a supportive senior management culture for such projects.

Projects are driven by the need to improve organizational effectiveness in existing markets, meet competition, develop new products/services for existing or new markets, and develop and implement new engineering, manufacturing, marketing, maintenance, and services necessary to bring the project from the idea stage through to customer use. In today's global competition strategic survival is dependent on how efficiently and effectively the leaders of the enterprise strategically manage new product/service and process technology usually through the use of project management techniques.

Once a project is funded and corporate resources are devoted to design, develop, and construct or manufacture the needed project, it becomes an important responsibility of the senior managers (including the board of directors) to maintain surveillance over the efficiency and effectiveness with which corporate strategy is being implemented through the use of projects. Large capital projects which encompass significant corporate funding require ongoing regular review by senior management as well as those small new product/service and process development projects which may enable the enterprise to meet or exceed the technology embodied in competitive products and services. In high-technology markets, the ability to conceive, develop, fabricate, and market a new product or service ahead of the competition can make the difference between success or failure. In a market where the existing technology is stable and mature there is always the risk that a new technology will emerge which makes a given strategy obsolete. For example, vacuum tube technology was made obsolete by the development of the transistor; radial tires replaced the dominant bias tires, and the computer has replaced the mechanical data processing systems. Current success in a given product or service can be displaced by an incremental or major technological change. By regularly reviewing the portfolio of projects that the enterprise has underway, senior managers can gain valuable insight into how well (and if) the enterprise is being positioned for survival and growth in the increasingly rapid pace of technological change underway in industry today. These projects usually fall into one of the following:

. "Pure" research projects which provide the basis for investigating the ability of a particular discipline to provide the technology to advance a product or process.

. "Applied" research projects providing for the integration of different disciplines into a product, service, or process improvement required to position the firm in its competitive environment.

. Construction and manufacturing projects through creating the means for the creation of something that did not previously exist in the firm but is needed to enable the firm to meet competition.

. Administrative and support projects to facilitate and sustain the services to market and maintain the project results (the product, service, or process) in the user's operating environment.

Success or failure in the manner in which projects are managed in the organization will have a significant impact on the firm's ability to compete in its operational business. It is for this reason that senior managers have an important responsibility to pay close attention to the "stream of projects" that are flowing through their organization since these projects, in one way or another, contribute to the organization's ability to survive in its future.

Prudent and reasonable management of a project contributes to an organization's future.

PRUDENT AND REASONABLE MANAGEMENT CRITERIA - AN INDUSTRY PERSPECTIVE

In determining "prudent and reasonable" management in the Nuclear Power Plant Industry, much of the focus falls on the project management role of the owners in adequately planning and controlling the use of resources on the project. The adequacy of senior management's performance in project management surveillance is evident in the following sampling of recent situations.

. Forbes magazine claims that the failure of the U.S. Nuclear Power Program ranks as the largest managerial disaster in business.[1]

. $1.2 billion of Long Island Lighting Company's increased costs for the Shoreham project were recommended for exclusion from the rate base as having been imprudently incurred.[2]

. The State of Alaska alleged before the Federal Energy Regulatory Commission that $1.6 billion in imprudent management costs were associated with the design, engineering, and construction of the $8 billion Trans-Alaska Pipeline System. A settlement on this case was reached on February 13, 1985. The agreement provides that: (1) the rate base will be reduced by $450 million in recognition of the State's allegations of imprudent management; (2) the oil companies will pay $35 million for the State's legal expenses in the proceedings; (3) the owners will refund about $750 million for excessive tariffs between 1981 and 1984; (4) the tariffs will be reduced immediately from about $6.20 per barrel to about $5.00; (5) tariffs will continue to decline throughout the term of the agreement based on an established formula; and (6) the terms of the settlement will apply even if the Federal Energy Regulatory Commission or Congress at some point decides to deregulate oil pipelines.[3]

. The State of Missouri Public Service Commission found that the design of the Union Electric Company's Callaway Nuclear Plant was not sufficiently complete when construction began and that the problem continued throughout the project causing inefficiencies and delays.[4]

. In a study of quality in the design and construction of nuclear power plants it was found that the root cause for initial quality problems was a failure of the utility to implement a management system that ensured adequate control over all aspects of the project.[5]

In the case of the Shoreham Project mentioned previously, the responsibility and accountability of the senior executives were made clear by the administrative law judges who concluded that:

> ...Lilco (Long Island Lighting Company) failed to develop a project plan adequate to oversee S&W management of the project. To identify roles and responsibilities, to develop accurate and timely reporting systems which would enable it to monitor, measure and control costs and scheduling, to adequately staff monitoring groups or to adequately prepare for its critical owner oversight role.
>
> We conclude that, throughout Shoreham's construction, Lilco failed to staff adequately its prime area of responsibility as owner of the plant-cost and schedule control.
>
> Lilco's measurement and reporting systems continually and repeatedly failed to accurately depict cost and schedule status at Shoreham. Lilco managers were unable to use Lilco's measurement systems to gain an accurate picture of what was happening on site and complained that Lilco's reporting systems were confused and cluttered.[6]

The law judges left no doubt as to the overall responsibility of the Lilco Board of Directors for the Shoreham Project:

> We conclude that the limited information presented to the Board was inadequate for it to determine project status on the reasonableness of key management decision or to provide requisite guidance and direction to Lilco management.

On the Diable Canyon Nuclear Plant Project a large part of the responsibility for the problems of that project rested with the board of directors. An expert witness testified:

> "The Board of Directors of Pacific Gas and Electric Company [PG&E] failed to take an active role in maintaining a reasonable level of surveillance during the early years of the Diablo Canyon Project. This lack of an active role was particularly detrimental during the first ten years of the Diablo Project. As a result of this neglect and lack of leadership by the Board, serious cost, schedule and technical considerations were left unattended at the highest levels of PG&E, which contributed significantly to the final cost and schedule overruns of the Diablo Project. Although PG&E claims that the Board and the Executive Committee of the Board were actively involved in matters concerning the Diablo Project, an analysis of the ... minutes of the Board indicated otherwise.
>
> The Board of PG&E was not diligent or prudent in its discharge of the trusteeship to the PG&E stockholders. This imprudence set a poor example for PG&E's senior management with responsibility for the management of the Diablo Project and promoted a cultural ambiance which did not support the rigorous contemporaneous project management system that was required.

Senior management, no doubt influenced by the Board's lack of concern for the Diablo Project, failed to provide adequate planning organization and control of the corporate resources used on the Diablo Project. PG&E senior management lost credibility with the NCR during a critical period of the project and failed to take an adequate leadership role in the efficient use of the resources devoted to the Diablo Project. Furthermore, the cultural ambience of the PG&E company with regard to the Diablo Project encouraged a lack of rigor in making and executing key decisions." [7]

In subsequent review and submission of rebuttal testimony by an expert witness on the Diablo Canyon Project it was found that:

. The information provided to the PG&E Board of Directors about the Diablo Project was inadequate to permit reasonable oversight.

. There were inadequate regular reports provided to the Board of Directors on the status of the project.

. Untimely board meeting agendas and materials relative to the project limited the director's ability to evaluate fully the status of the project.

There was little if any involvement by the PG&E Board of Directors in key strategic decisions and actions on the Diablo Project. These decisions and actions included:

- Approval of a strategic plan for Diablo.
- PG&E's decision to act as its own architect, engineer and construction manager.
- Choice of a basic organizational structure for the project.
- Assessment of the suitability of the Diablo Canyon site.
- Assessment of the implications of the Hosgri fault.
- Full assessment of the implications of the Mirror Image Error.
- Selection of Bechtel Power Corporation as Project Completion Manager. [8]

In addition, there are other critical comments of a more general nature such as Davis' remark that capital expenditure overruns and poor performance are symptoms of a widespread problem affecting pioneer projects.[9] Bates noted that owners have paid inadequate attention to soaring construction costs and reasons for them. [10]

A Rand Corporation study of new technology process plant construction finds that the most prominently mentioned management-related reason for increased costs in "diffuse decision-making responsibility for a project." The study concludes that the "general wisdom for construction projects" dictates that "one person needs to be given broad authority for all routine project decisions and a reasonable scope for fairly important decisions on schedules, allocations of monies, and all but major modifications." The study finds that it is "standard industry practice to appoint a project manager -- in the case of a pioneer plant project, a project manager of long experience, who is responsible for the undertaking from shortly after the time that the project emerges from development until an operating plant is on-line." [11]

## REACTION BY SENIOR MANAGERS

Davis has noted that senior managers' most important task is to foster a corporate environment that facilitates honest and frank disclosures in dealing with a budget-breaking budget. He further notes that the management style of the senior executives has much to do with whether or not coverups and recriminations are discouraged. [12] A corporation whose senior executives do not commit themselves to comply with government regulations sends an important message throughout the organizational hierarchy. On the other hand, a senior corporate management that takes the lead in developing and promulgating policies that demand full cooperation and disclosure to government bodies will find such policies echoed and enforced throughout the company's organizational structure.

For example, in the nuclear plant construction industry, the Nuclear Regulatory Commission (NRC), found a direct correlation between the project's success and the utility's view of NRC requirements. More successful utilities tended to view NRC requirements as minimum levels of performance, not maximum, and they strove to achieve increasingly higher, self-imposed goals. This attitude covered all aspects of the project, including quality and quality assurance. [13]

In contrast, during a performance audit of a large project it was found that the attitudes, values, beliefs and behavior demonstrated by senior management of the organization were detrimental to the successful outcome of the project. In an assessment of this project, it was found that senior management had condoned a culture which contributed to various problems on the project with significant injurious results such as: (1) a lack of candor and openness in dealing with government agencies, particularly the NRC; (2) management leadership which encouraged the destruction of documents which might have negatively affected the company during customer rate litigation; (3) a lack of commitment to adequate communications within the company concerning the status of the project; (4) not taking a conservative approach to unknown factors in the design and construction of the project; (5) the general lack of leadership to resolve problems on the project in a timely manner; and (6) reliance on past management philosophies and practices and a failure to recognize the impact of new technology on both the design of the project and the use of contemporaneous project management practices. [14]

The cultural ambience that is encouraged by the senior management of the enterprise in turn will influence the way the project team thinks about its responsibilities in managing the project. During review of the project by the senior managers the full status of the project should be considered, both of the project itself, and also the linkages that the project will have in its greater "systems environment" which includes the technological, social, economic, political, legal, and competitive conditions in which the project exists. Project managers need to identify and interact with key institutions and individuals in the systems environment to identify and manage input that might have an impact on the project's current status and its outcome. An important part of the management of the project's systems environment is an organized process for identifying and managing the probable stakeholders in that environment. This management process is necessary in order to determine how the probable stakeholders are likely to react to project decisions, what influence their reaction will carry, and how the stakeholders might interact with each other and the project team to affect the chances for success. [15]

## PROJECT STAKEHOLDERS

An important part of the review of the project by senior managers is to determine if the project team is aware of the potential impact of the project's stakeholders and if care is being taken to manage these stakeholders. There are good examplles of projects that got into difficulty because of some key stakeholders' claims that were not recognized by the project team (and the senior managers of the enterprise) until such stakeholders had sufficient power and political influence to cause serious and costly problems for the project. In some cases the power of key stakeholders became so dominant in the interfacing political systems that the required additional funding for the projects was not forthcoming, resulting in the termination of the project. If the senior managers require that each review of the project includes an ongoing assessment and status of actual and potential stakeholder claims, then there is a greater opportunity for the project team and the project owner to collaborate on the development of a project strategy for dealing with the stakeholders. Such involvement by the senior managers will send an important message throughout the organization and create a cultural awareness of the role of project stakeholders. If senior management neglects or is indifferent to the project stakeholders, this attitude will be mirrored in the behavior of the project team.

Some examples of successful and not-so-successful stakeholder management contain a prime message about the importance of stakeholders:

. Care was taken to develop early and continuing cooperation among stakeholder groups concerned with environmental impact and transportation relative to the development and construction of a large sports complex in the U.S. This care averted any adverse impact of these groups on the project's cost and schedule.

. The project manager on the U.S. Apollo Space Program gained the early and unbroken support of the Aerospace Industry, Congress, the Scientific Community, and related constituencies which contributed in a major way to the success of that program.

. In the conceptualization, design, engineering, and construction of a computer-integrated manufacturing facility, careful attention was given to involve key stakeholders in the project planning process. Key executives, the project team, suppliers, subcontractors, workers, union members, local community members, local government officials, financiers, architects, constructors, and trainers worked together as a team to put the plant into its operational mode within an incredibly short time of sixteen months.

. Over the past five years the General Motors Corporation has spent approximately $39 billion on plant and equipment projects to modernize their engineering and manufacturing facilities. After the modernization program was initiated, it was found that some stakeholders - the workers - had not been adequately considered through training and indoctrination, and failed to fully subscribe to the new ways of manufacturing. CEO Roger Smith stated:

> But I sure wish I'd done a better job of communicating with GM people. I'd do that differently a second time around and make sure they understood and shared my vision for the comopany. Then they would have known why I was tearing the place up, taking out whole divisions, changing our whole production structure. If people understand the why, they'll work at it. Like I say, I never got all this across. There we were, charging up the hill right on schedule, and I looked behind me and saw that many people were still at the bottom, trying to decide whether to come along. I'm talking about hourly workers, middle management, even some top managers. It seemed like a lot of them had gotten off the train. [16]

Today this has changed; workers who once were expected to be quiet and follow orders at GM are now encouraged to use their knowledge and skills in the overall improvement of quality and productivity.

Project stakeholders are often involved in the "strategic issues" facing a project.

## STRATEGIC ISSUES IN PROJECT MANAGEMENT

A strategic issue is a condition or pressure, either internal or external, that will have a significant effect on one or more factors of the project, such as its financing, design, engineering, construction, and operation of the project's product or service. King has put forth the notion of "strategic issue management" as an integral element of the strategic management of organizations, [17] and

Brown and Ansoff have also dealt with strategic issues in the management of organizations. [18] Examples of strategic issues that have impacted the management on select projects include:

. On the U.S. Supersonic Transport Program the managers had a narrow view of the stakeholders and generally dismissed the impact of the environment-related strategic issues until it was too late. Environmentalists, working through their political "networks" succeeded in stopping that program.

. The Tennessee-Tombigbee 234 mile-long waterway which cost over $2 billion was beset with political considerations, lawsuits, environmental concerns, and social factors over many decades. Although it took 14 years to build this waterway, it was some 175 years in the making during which it was subjected to many strategic issues which were subsequently resolved.

. On the Diable Canyon Nuclear Power Plant the discovery of an earthquake fault a few miles offshore set in action a strategic issue which eventually resulted in the redesigning of the plant at a cost of nearly $2 billion. There was little evidence that the senior managers of the owner organization demanded and received a satisfactory accounting or made any relevant in-depth inquiry to determine its full ramifications. Instead, construction was continued on the plant until a redesign was ordered by the Nuclear Regulatory Commission.

. In the U.S. today there are many strategic issues that face the Nuclear Plant Construction Industry: Passive safety, construction costs, nuclear waste management, and advocacy, to name a few. Of these issues the lack of a broad political support base and the lack of an effective and influential champion for nuclear power has stopped any new plants in the U.S.

. On a smaller scale, a circumferential highway under construction near a large U.S. city required the razing of an old Catholic church which had historical and emotional value as a landmark to the local church members and the national church organization. The project team failed to recognize the strategic issue that this church posed and went ahead with construction. Political alliances, public protests, and eventual court involvement resulted in the highway's being rerouted at an increased cost and a project schedule delay of nearly three years.

When strategic issues arise in the management of a project or within the organization's environment they may motivate the use of project management techniques to accommodate the issue. For example, intense foreign competition in the U.S. automobile industry has prompted American automobile manufacturers to develop management innovations in the design of their cars. Cutting costs and car design-development time are key strategic issues facing U.S. producers Their response to these issues has in part been through project management techniques that use product design teams to cut across design, manufacturing, engineering, finance, marketing, and supplier organizations. The result -- shorter model-to-product-to market development cycles with consequent cost savings, improved quality, and a more competitive product in the world car market. Project teams have also been used in the automobile and other industries to respond to the need to automate factories on a timely basis.

It is important that both the project team and senior management understand the concept of strategic issues and how an awareness of the project's strategic issues can facilitate the successful management of the project.

## SENIOR MANAGEMENT'S RESPONSIBILITY

The senior manager's involvement in facilitating and propagating a supporting management system for the strategic management of projects in the organization is critical. Much of this depends on the attitudes that senior managers have about project management and the actions they take in meeting their responsibilities in the strategic management of the enterprise's projects. These strategic management responsibilities include:

. A recognition that projects are building blocks of organizational strategy which when completed make a contribution to the operational performance of the project owner.

. An awareness that an important part of the review of any project is a determination of the "strategic fit" of the project in supporting the enterprise's mission, objectives, and goals.

. Assuring that careful consideration is given to an examination of the real and potential impact that the project stakeholders can have on the project and that such stakeholders are managed.

. Regular, ongoing review of key projects underway in the enterprise so that senior managers know the adequacy of the management of the projects in terms of project plans, project organizational design, and policies, procedures, and systems for the continuing monitoring, evaluation, and control of the enterprise resources used on the project.

. Acceptance of the notion of the key role that strategic issues and stakeholders can play in the outcome of a project and ensure that the project team is aware of and prepared to deal with such matters as distinct work packages in the management of the project.

. Recognize the importance of the cultural ambience of the enterprise and the role that the organizational culture can have in facilitating an effective and efficient management of the projects.

. Approach each review of the project with an open mind towards the option of project termination through the establishment of limits beyond which continued expenditure of resources on the project just doesn't make strategic sense.

. Conduct post-project appraisal on major projects and develop a profile of "lessons learned" from such appraisals for use in improving the state-of-the-art of project management in the organization as well as the culture ambience for the more prudent management of projects.

If senior management becomes involved in the projects, an important message is sent throughout the enterprise: "These projects are important to our future and should be carefully managed by all concerned."

## SUMMARY

Commercial projects have had their problems. Schedule and cost overruns, inadequate technical performance of the project results expressed in a product, service, or manufacturing/production process are found all too often in commercial projects.

Assessment of project "failure" - the inability of the project to be completed on time, within budget and capable of the desired technical performance - rests with the project team and with the senior managers of the project owner's organization. Senior managers must provide for adequate review of the project proposal, and the effectiveness and efficiency with which the project is executed during its life cycle. Approval of the organizational design, and the project plans and control processes is an important responsibility of the senior managers. During the project's life cycle the senior managers must maintain surveillance over the project's use of resources and whether or not the project continues to have a strategic fit in the design and execution of organizational strategies.

An ongoing surveillance over the stream of projects in the organization provides the senior executives key insight into how well the organization is preparing itself for its future.

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# STRATEGIC PLANNING: AN EXAMINATION OF THE PROCEDURES, CRITICAL SUCCESS FACTORS, AND PERFORMANCE FEEDBACK ELEMENTS DEVELOPED AND IMPLEMENTED BY THE NAVAL AIR SYSTEMS COMMAND

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## ABSTRACT

*Making the business of tomorrow cannot be a flash of genius. It requires systematic analysis and hard, rigorous work today - and that means by people in today's business and operating within it [5:47].*

Peter Drucker

The following paper presents the general framework of the strategic planning process developed and implemented during 1988 by the Naval Air Systems Command (NAVAIR). This framework encompasses an array of current and historical literature on long-range, corporate and strategic planning principles tailored to the unique needs of the command.

The approach taken by NAVAIR represents the culmination of extensive efforts largely directed and supported by the Commander, Naval Air Systems Command along with the top management leadership structure. The strategic planning process, although rather new in its total command-wide application, is not new in theory. For several years, strategic planning at NAVAIR has been evolving through a series of iterative steps beginning with generic command goals and objectives to a more formal, precise and measurable system with built-in feedback mechanisms.

This paper is intended to demonstrate (1) that NAVAIR's strategic planning efforts are theoretically based and (2) the effectiveness of teamwork and commitment in developing and implementing a structured process designed to enable NAVAIR to successfully meet future mission requirements through ongoing internal (organizational) and external (environmental) evaluation, change and process/system improvement.


## INTRODUCTION

The planning efforts that currently exist within the Naval Air Systems Command (NAVAIR) cannot be presented without reviewing some of the theoretical perspectives underlying them along with the procedural history. The authorities selected in this paper represent various organizational backgrounds and experience levels and provide a mainstream of current opinion on the merits, development and implementation of strategic planning.

For purposes of this paper, the author intends planning to mean *strategic* planning including establishing and implementing a formal, functionally-interdependent process-oriented means for determining and evaluating the organization's long-range strategies, promulgating these strategies, identifying objective performance indicators and instituting a systematic, ongoing performance feedback monitoring procedure.

This interpretation of strategic planning acknowledges that several processes and systems within the organization are linked and must be taken into account prior to developing a strategic planning approach. King and Cleland [10:21] indicate that "a more modern approach to strategic planning recognizes the interdependence of planning and other functions and activities in the organization and attempts to take cognizance of these interdependencies in designing the organization's planning systems, information systems, and other processes and systems." We will be examining some of the factors involved in NAVAIR's strategic planning process later in this paper.

A multitude of contemporary research on strategic planning suggests that formal strategy analysis and the development and implementation of a strategic planning process do in fact have a positive impact on organizational performance. There has been, in recent years, a growing recognition that strategic planning is essential in today's rapidly changing world. In addition to the potential advantages it offers, strategic planning is necessary for organizations to deal with rapid environmental change.

According to Thompson and Strickland [13:58-59], there are several significant advantages which surface from having a consciously formulated strategy. These include:

(1) the guidance it provides to the managers of organizational subunits;

(2) the contribution it makes to identifying strategic issues and to coordinate management's direction-setting decisions;

(3) the rationale it provides top management in deploying organizational resources among various activities and in evaluating competing requests from organizational subunits for corporate funds; and

(4) the desirability of trying to *influence* rather than merely *respond* to product-market-technological-environmental change.

Hax and Majluf [7:2] from the Massachusetts Institute of Technology also note that

> *"the primary contribution of a formal strategic planning process is the orderly identification of a well structured set of tasks, their delegation to the proper individuals within the organizational structure, and their execution in accordance with a prescribed schedule. The final effect of this process is a coordinated effort that demands a better balanced time allocation to each managerial activity."*

There are strategic differences among various types of organizations which reinforces the need for different planning and change control systems. For example, corporate-level strategies are different for functional and matrix-structured organizations. As a result, any discussion of planning must begin with a broad look at the structure, purpose and historical planning efforts of the organization being examined. The following two sections address these factors.

## ORGANIZATION

NAVAIR is a complex, dynamic and highly diversified Department of the Navy acquisition and logistics support organization responsible for developing, procuring and supporting all the aviation systems and their related equipment used by the Navy and Marine Corps, including the latest fighter and attack aircraft, helicopters, air-delivered weapons and some surface and submarine-launched weapons. The command is unique in that it oversees the entire life cycle of each aviation system from basic research until their service lives become obsolete.

NAVAIR is a three-star command organized as a matrix structure with headquarters in Washington, DC and twenty-eight field activities throughout the United States and abroad. To perform its critical mission, NAVAIR has a military and civilian personnel complement of some forty-eight thousand and an annual budget in excess of 16 billion dollars. NAVAIR's twenty-eight field activities include depots, engineering centers, test facilities, plant representative offices and other support organizations. These activities provide a wide range of services including aircraft overhaul and repair, engineering development and support, test and evaluation, contract administration, logistics support and other administrative functions.

## HISTORICAL EFFORTS

Prior to 1988, NAVAIR's corporate and strategic planning functions essentially consisted of a corporate-level, staff-generated set of command goals and objectives which were reviewed and signed by the Commander, NAVAIR (COMNAVAIR) and distributed throughout the command (both headquarters and field activities). Although command goals and objectives were promulgated, individual divisions within headquarters and the field activities were responsible for interpreting the broad guidance and translating this into their own specific applications. Progress reports to COMNAVAIR existed in the form of program management reviews for headquarter divisions and annual management reviews for the field activities. This is not to say that effective planning was not being done, but the planning was basically *operational* in nature and not necessarily oriented towards the future.

The first NAVAIR Corporate Plan was developed in 1986 and included sections on the organizational structure, environmental factors, various posture statements, high-level guidance and initiatives, budget/procurement elements and more detailed command goals, objectives and special emphasis areas. Special emphasis areas are those problems, processes or activities targeted by COMNAVAIR as requiring intense management focus and may include such items as obligation rates, safety, budget execution, quality of life, etc. The 1986 Corporate Plan also included a section that demonstrated the criticality of linking existing performance evaluation criteria to the goals, objectives and special emphasis areas.

This first NAVAIR Corporate Plan was significant in that it:

(1) articulated an analysis of environmental and some organizational considerations;

(2) demonstrated a clear need to establish accountability for meeting established goals and objectives; and

(3) provided a baseline from which to begin developing a more formal, structured planning process.

The second NAVAIR Corporate Plan, approved in August of 1987, in effect updated, clarified and expanded information contained in the first plan.

The major addition in the 1987 plan was a section highlighting significant command accomplishments. This section listed the command goals, objectives and special emphasis areas from the prior year and, through a formal data call throughout the command, elicited achievements in order to provide some basic feedback to NAVAIR employees relative to the success of meeting targeted goals, objectives and special emphasis areas.

During this timeframe, NAVAIR established a team to evaluate prominent organizational and procedural issues throughout the command. As a result, in April 1988, COMNAVAIR issued a memorandum which incorporated recommendations generated by the "NAVAIR 90" study team. This memorandum addressed those key actions necessary for the command to enhance and improve the way business is conducted *well into the future.* A very important action identified by COMNAVAIR [14:1] was that

> *"the command needs to look into the future in a more formal manner. The recommendations to involve at least all of the deputy and assistant commanders in the process are good ones. We should have regular and recurring meetings, some of them off site, to more formally address development of strategic plans which can be translated into operational objectives and tasks."*

Figure 1 shows that NAVAIR during the past five years moved from a top-down change-directing organization towards one which recognizes the necessity of a formal, command-wide planning approach to change.

## PLANNING FORMULATION

Constraints imposed by limited resources, governmental regulations/initiatives, technological change, product mix and a host of other elements preceded NAVAIR's recognition that something needed to be done to enable the command to meet future mission requirements. Change was inevitable. The initial reaction to using "strategic planning" was not just to pay lip service to the term, but to realistically delineate the requirements to be considered, evaluated and included in a formal planning process.

Procedures. Literature suggests that an important factor in the success of introducing strategic planning into an organization is largely dependent upon the commitment by responsible executives and managers to succeed [5:128; 6:6.6-6.7; 10:329]. As noted earlier, COMNAVAIR's support and commitment to a formal planning process filtered throughout the command. From this, a plan of action and milestones was developed, Planning Board Members were identified (members include the Deputy and Assistant Commanders, field activity representatives and other top NAVAIR executives), and a series of small, informal planning meetings were conducted with planning members to begin paving the way for strategic planning.

In addition to ongoing informal planning meetings, three primary and important strategic planning sessions were held. The theme overarching the sessions was, "Today's Leadership Controls Tomorrow's High Performance." This theme is consistent with Peter Drucker's definition of what strategic planning is. According to Drucker [5:125],

| 1984 1985 | 1986 1987 | 1988 1989 |
|---|---|---|
| - Top-Down Direction of Corporate Goals | -Top-Down Direction of Corporate Goals | - Strategies, Goals & Objectives from Participative Planning |
| - Limited Scope | -Broadened Scope | - Extensive Feedback System |
| - Marginal Feedback | - Limited Feedback | - Formal Accountability |
| | | - Performance Indicator System |

Figure 1

The following describes the planning formulation, implementation and performance measurement/feedback elements of the command's strategic planning process.

> *"Strategic planning does not deal with future decisions. It deals with the futurity of present decisions...The question that faces the strategic decision-maker is not what his organization should do tomorrow but 'What do we have to do today to be ready for an uncertain tomorrow?'"*

Figure 2 below summarizes the purpose, preparation, procedure and product of each session.

## STRATEGIC PLANNING SESSIONS

| | CHARLOTTESVILLE<br>18 - 19 August 1988 | FORT BELVOIR<br>28 September 1988 | HEADQUARTERS<br>24 October 1988 |
|---|---|---|---|
| PURPOSE | (1) Gain early participation, support, and commitment of key executives to developing and implementing strategic planning process<br>(2) Foster team approach to establishing Command strategies, goals, objectives for two-year timeframe<br>(3) Ask questions strategic in nature | (1) Evaluate objectives and performance indicators developed by functional groups and line managers<br>(2) Refine mission, strategies, goals and special emphasis areas | (1) Finalize mission, strategies, goals, objectives, performance indicators, special emphasis areas |
| PREPARATION | - Informal planning meetings<br>- Team building<br>- Reading material on strategic planning distributed to planning members; literature review<br>- Examination of internal/external factors and influences (assumptions/assessments)<br>- Briefing prepared by each planning member | - Planning package with proposed objectives and performance indicators distributed and reviewed prior to planning session<br>- Minutes from Charlottesville Round<br>- Ongoing interaction with COMNAVAIR | - Completed planning package with Command mission, strategies, goals, objectives, performance indicators and special emphasis areas distributed and reviewed<br>- Ongoing interaction with COMNAVAIR |
| PROCEDURE | - Formal 20-mt briefings by planning members<br>- Team-approach<br>- Planning member active particieption<br>- Delphi technique, series of rounds to determine strategies, goals and special emphasis areas<br>- Evaluation, prioritization, selection of strategies, goals and special emphasis | - Planning member active participation<br>- Open discussion forum<br>- Critical evaluation of objectives, performance indicators and associated resources; mission, strategies, goals and special emphasis areas reviewed | - Planning member active participation<br>- Open discussion forum<br>- Final evaluation of Command strategies, goals, objectives, performance indicators, special emphasis areas and mission |
| PRODUCT | - Preliminary Command strategies, goals and special emphasis areas<br>- Revised mission statement<br>- Strategy sponsors appointed | - Refined Command strategies, goals, special emphasis areas and mission statement<br>- Preliminary set of objectives and performance indicators | - Comprehensive Command strategies, goals, objectives, performance indicators, special emphasis areas, mission statement ready for publication in 1989/90 NAVAIR Corporate Plan<br>- Accountability and responsibility identified |

Figure 2

A planning needs assessment was conducted throughout each of the formal planning sessions. Brandt's [4:10] dimensions of strategic planning, Figure 3 below, shows that various levels of planning, stages of organizational growth and strategic questions are primary elements when conducting a planning needs assessment. Manzini and Gridley [11:6] wrote that "for organizations embarking on the development of an integrated strategic planning system for the first time, the initial requirement is an often painstaking analysis of the organization itself, its past history, present strengths and weaknesses, current policies and procedures, and prospective plans." Each of these elements were covered in detail during the major strategic planning sessions.

## STRATEGIC PLANNING DIMENSIONS

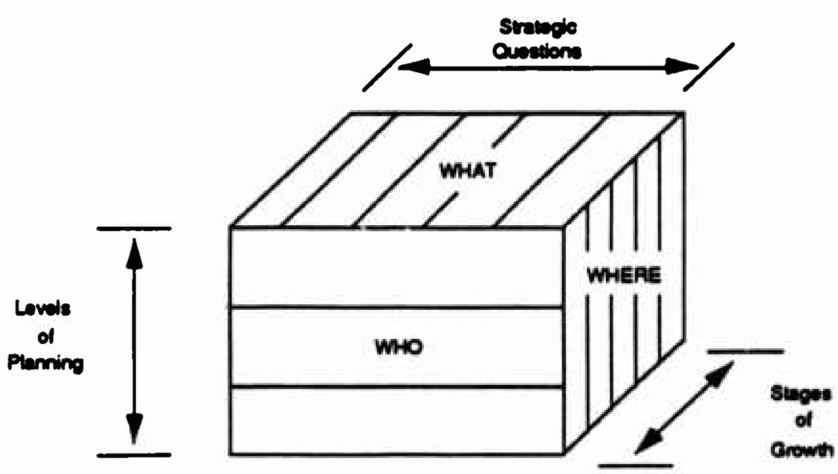


Figure 3

The timeframe between the three major planning sessions was very important. Given that planning occurs at various levels within the organization, different planning efforts must be recognized and included in this process-building phase. During these interim periods, extensive planning efforts occurred in which command executives interacted with functional and division managers along with corporate planning staff members to define, evaluate and refine objectives in support of command strategies and goals. This interaction fostered top-down, bottom-up communication throughout the organization which enabled managers and other staff to contribute to the process being developed. We find that

> *"The top-down-bottom-up element of a corporation's strategic management process is an effective communications device because it is both interactive and iterative. It permits managers at each organizational level to contribute a particular perspective and ultimately reconcile differences which may exist between senior management's top-down portfolio strategy and group and divisional bottom-up specialized business approaches. The exchange results in agreed-upon strategies which are thoroughly understood, and a commitment on the part of each manager" [2:3-9].*

Critical Success Factors. The critical success factors discussed here are those key variables defined by planning board members as important for evaluation prior to developing a formal planning process. Examination of these factors contributed heavily to the planning needs assessment. The shadowed areas in Steven C. Stryker's [12:12] following schematic (Figure 4) represent the critical success elements touched upon by the planning sessions.

PHASES OF STRATEGIC PLANNING

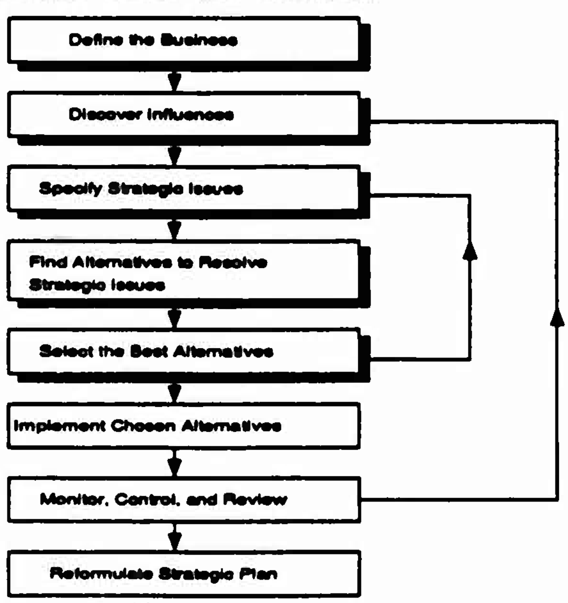


Figure 4

We will examine these in more depth as it is significant to recognize the amount of progress achieved by NAVAIR over a relatively short timeframe.

Define The Business. Peter Drucker [5:77-79] stressed that the question, "What is our business?" although simplistic and obvious in nature, is one most neglected by managers and is often the most important single cause of organization frustration and failure. Drucker firmly believes that the only way this question can be answered is by taking the point of view of the customer. NAVAIR executives took great pains to identify their customers, customer requirements/needs and how to best meet these needs. This coincides with Derek Abell's [1:169] three-dimensional concept of defining "What is our business?" Figure 5 below demonstrates this concept.

DEFINING A BUSINESS

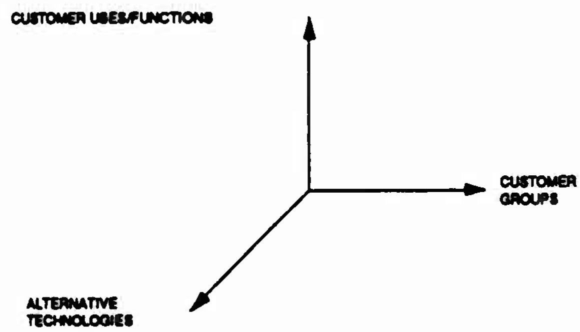


Figure 5

According to Abell, defining an organization's business is a joint relationship between identifying who the customers are, their requirements and how are their needs best satisfied. One of the end products from the executive planning sessions was a reevaluation and redefinition of NAVAIR's mission statement. This revised statement addresses, "What is our business?"; "What should our business be?"; and "What will our business be?" The mission statement now provides specific details about NAVAIR's purpose, customer groups, needs and the range and quality of technologies, services and products to be provided.

Discover Influences, Specify Strategic Issues, Find Alternatives to Resolve Strategic Issues, Select the Best Alternatives. A great deal of literature has been published on the importance of understanding both the internal organizational structure and external conditions for occurrence of effective strategic planning. Once the influences have been determined, strategic issues and alternatives can then be articulated and evaluated and the best alternatives for resolving such issues selected.

Internal Influences. Understanding the organization's internal structure and processes and evaluating its actual and potential strengths and weaknesses are necessary prerequisites to establishing a strategic planning process. D.E. Hussey [9:87] noted that "the corporate appraisal should be one of the first steps in the process of preparing long-range plans, and should provide both the platform from which the corporate objectives are established and the baseline of the strategic plan." Internal analyses often lead to planning data that can be quite useful in determining/selecting the *best or alternative* planning scenarios. Such analyses should focus on human, financial, physical and technological resources from historical, current and futuristic perspectives.

External Influences. Hax and Majluf [7:15] state that "environmental scanning attempts to diagnose the general health of the industrial sector relevant to the business in which the organization is engaged. Furthermore, it concentrates on assessing the overall economical, political, technological, and social climate that affect the corporation as a whole." Recognizing and identifying significant environmental elements are necessary to preclude selection of a planning process that does not permit contingencies or evaluation of alternatives. Before the organization's future can be determined or even addressed, technological, social, political, legal, and economic factors must be understood.

Planning board members recognized the importance of evaluating historical, current and future corporate positions from <u>both</u> internal and external perspectives. Detailed analyses were conducted and a set of assumptions concerning past and current organizational structure and performance, application of resources and mission goals were generated in order to establish a baseline from which to begin further analyses. From this, a series of assessments were presented and discussed concerning potential mission requirements. An analysis of the variance between internal capabilities and external impacts was then performed to depict the command's current corporate abilities and to determine what critical path and planning elements the command would need to implement in order to overcome identified strategic issues and to meet and support future requirements. <u>Figure 6</u> highlights the areas evaluated by the planning members and the basic process involved.

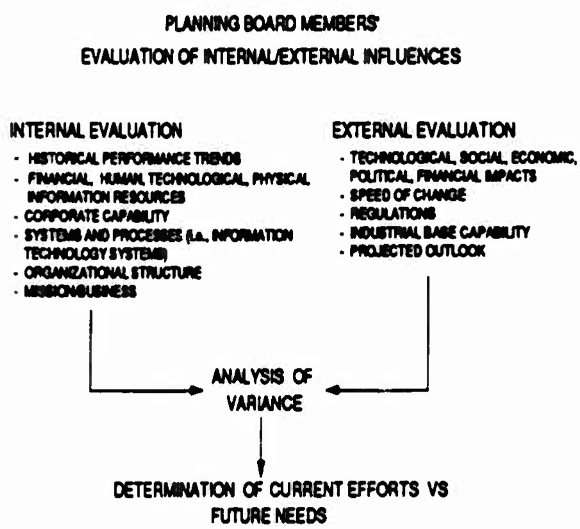


Figure 6

<u>Figure 2</u> demonstrates that planning members specified influences and identified strategic issues along with proposed alternatives. This was done largely by the Delphi technique in which a series of rounds were held to identify, evaluate and prioritize strategic issues and subsequent proposed strategic alternatives. Literature suggests that the Delphi technique provides a more efficient and less biased way to use the information held by key decision makers (in evaluating alternatives) than that provided by informal methods [2:2-9].

The primary products derived from these aforementioned critical success factors were (1) the generation of a viable set of options from which to select the best course of action ensuring corporate growth and sustainability while providing the flexibility necessary for change and (2) the actual selection of realistic, achievable strategies, goals, objectives and performance indicators.

In summary, Manzini and Gridley [11:74-75] have written,

> *"No approach to planning can succeed without a clear view of the existing situation. This basic evaluation of existing resources, financial goals and projections, and immediate prospects forms a baseline for evaluating the current strengths and weaknesses as an organization, which together with a sharpened view of organizational objectives gained from core mission analysis and information on the external environment, forms the starting point for the development of scenarios depicting different organizational futures."*

The following represents the effective translation of these results into a viable system of documentation, direction and performance feedback.

## PLANNING IMPLEMENTATION

<u>Documentation</u>. The most basic output of planning formulation is a planning document. A planning document conveys to organizational elements the planning results formulated for a specified period of time and identifies the organization's priorities for resource allocation. Planning documents may be broad mission plans outlining generic strategies for future accomplishment or may be detailed, highly complex plans with associated resources, milestones and accountability. King and Cleland [10:25] discuss the concept of a "system of plans" in which the organization's plans are interrelated and interdependent. The relationship between the organization's plans is critical for ensuring that consistent decisions are made throughout the organization. This relationship is equally important for ensuring that the plans mesh with overall corporate goals.

NAVAIR has two major organizational plans, the Corporate Plan and Business Plan. NAVAIR, in developing the plans, concentrated on accurately and clearly articulating the strategic choices made, defining the relationship between the plans, ensuring consistency between the plans and defining associated corporate-level/functional group responsibilities.

Corporate Plan. The end result of NAVAIR's informal and formal planning sessions was the promulgation and distribution of the 1989/90 NAVAIR Corporate Plan. This document is the two-year strategic plan which integrates major policies, initiatives and actions into a cohesive document communicating broad strategic planning guidance throughout the command. The total package of mission statement, strategies, goals, special emphasis areas and objectives form the core of the Corporate Plan.

Business Plan. In support of the Corporate Plan, the functional groups within headquarters and the field activities prepared annual business plans. Business plans are the operational or day-to-day plans which not only reflect the guidance generated by the Corporate Plan but expand this guidance to provide more specific, concise and detailed objectives to employees. The business plans function as work "blueprints" and contain objectives and measurable performance indicators tailored to each group's unique needs and requirements. The performance indicators identify specific timeframes and responsible personnel for accomplishing stated objectives and are a vital part of the performance feedback and measurement system.

Figure 7 represents NAVAIR's planning process in its simplest form.

PLANNING PROCESS

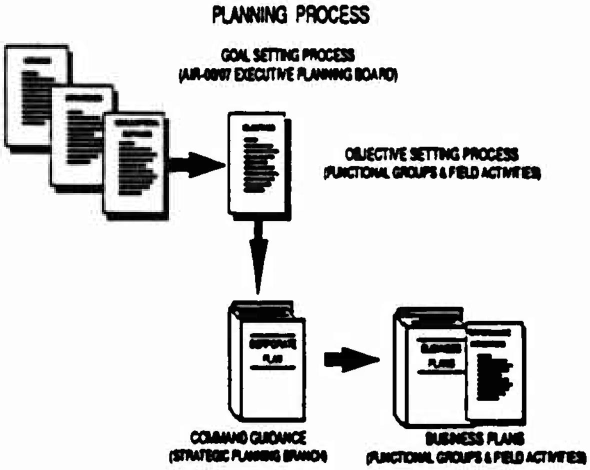

Figure 7

PERFORMANCE FEEDBACK AND MEASUREMENT

The effectiveness of a planning system may be thought of as the value added to management decisions and actions and any subsequent impact to the achievement of strategic goals. Evaluation of the results derived from both the planning formulation and implementation phases is vital to determining the system's effectiveness and for ensuring continual corporate growth. King and Cleland [10:349-350] noted that "a planning system that does not have a strategy for review and improvement of the efficacy of strategic-planning efforts in the organization is unlikely to achieve its fullest potential."

Performance Feedback. NAVAIR's performance review process is shown in Figure 8.

REVIEW PROCESS

Figure 8

The performance review process developed by NAVAIR is basically a two-fold approach. Figure 9 shows one side of the feedback process whereby field activity and air group commanders report their achievements relative to the goals, objectives and performance indicators set forth in their business plans during the Annual Management Review (AMR). This forum enables field activity and air group commanders to present and discuss accomplishments, issues or problems in meeting the prior year's targeted goals.

The other side of the review process occurs on an annual basis during the NAVAIR Commander's Conference (Figure 10) where the Corporate AMR is presented. The Corporate AMR will provide a formal review of Corporate strategies, goals and objectives and will analyze performance criteria and any reasons for deviation. Strategy sponsors will report on progress made towards accomplishing command strategies with special attention to objectives and special emphasis areas. The Executive Planning Board, chaired by COMNAVAIR, will then meet to revise goals, objectives and special emphasis areas as necessary. The first Corporate AMR is planned for October 1989.

In addition to the AMRs, a series of smaller-scale briefings are presented to COMNAVAIR during his regularly scheduled staff meetings. Strategy sponsors during these briefings discuss current efforts in meeting established strategies and special emphasis areas.

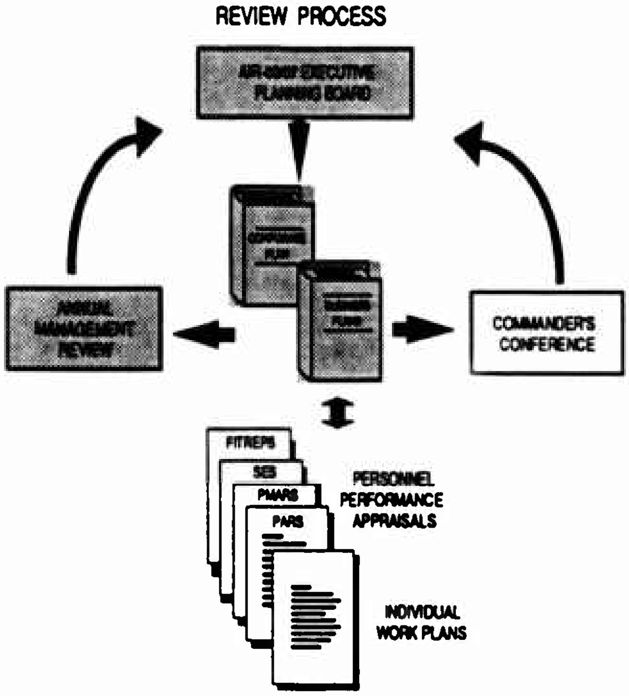


Figure 9

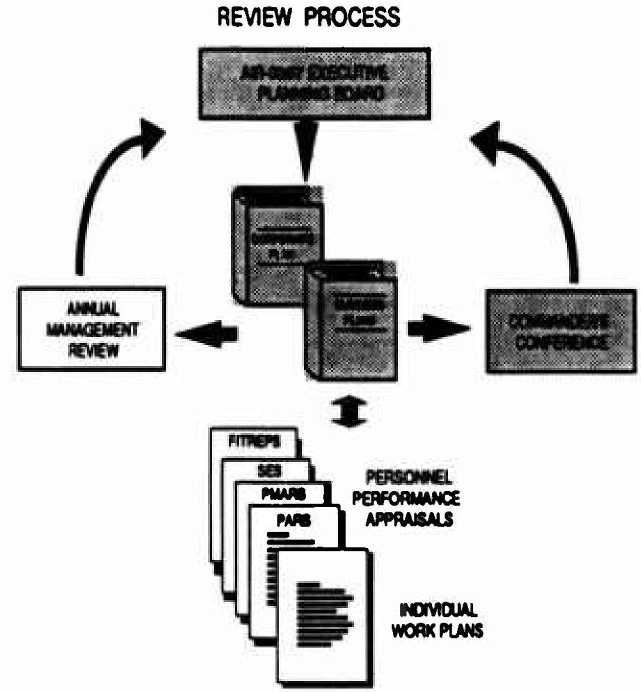


Figure 10

Another facet to the command's feedback process includes personnel performance appraisals (shaded areas in Figure 11). The planning process, in order to be fully effective, needs to be integrated into individual performance recognition systems. We tend to find that organizational performance is effective to the extent that individual efforts are successfully directed toward organizational goals in an atmosphere deliberately created to encourage the development of required skills and to provide the satisfaction of personal progress [3:132]. This provides the organization an opportunity to evaluate performance (at the lowest echelons) against command goals and objectives. NAVAIR's planning guidance specifies that military and civilian performance appraisals should reflect specific responsibility and accountability for accomplishing command goals and objectives. From this, individual work plans should be developed that appropriately reflect the goals and objectives outlined in the individual performance appraisals.

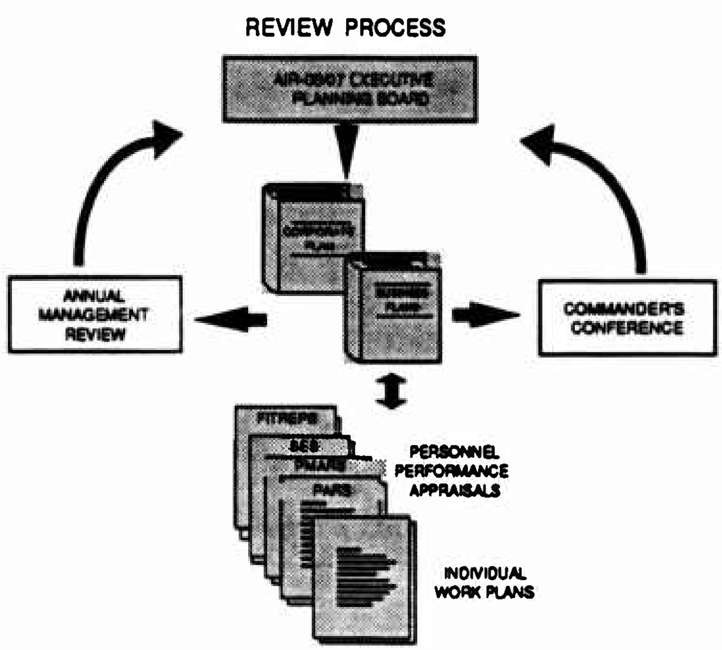


Figure 11

Total Quality Management. Currently, NAVAIR is implementing Total Quality Management (TQM) commandwide. TQM, although thought of primarily as a comprehensive management philosophy, is being utilized as a performance feedback mechanism to evaluate the effectiveness of command strategies, goals and objectives. Figure 12 addresses the TQM feedback structure being discussed in the following paragraphs. This is important to recognize as it functions as a process-oriented feedback mechanism examining the work productivity and quality involved towards accomplishing stated items. This is consistent with Peter Drucker's explanation of making work productive.

TOTAL QUALITY MANAGEMENT PERFORMANCE FEEDBACK

| ELEMENT | RESPONSIBILITIES | OPERATION |
|---|---|---|
| EXECUTIVE STEERING COMMITTEE | - PROVIDE FOCUS<br>- ESTABLISH POLICIES<br>- PROVIDE RESOURCES | - ESTABLISH/DISSEMINATE STRATEGIC GOALS<br>- BUILD CONSTRUCTIVE INTERFACE WITH CUSTOMERS AND SUPPLIERS<br>- PROCESS SELECTION/PRIORITY<br>- QUALITY MANAGEMENT BOARD REVIEWS AND RESOURCING<br>- REVIEWS/EVALUATIONS<br>- FACILITATE MANAGEMENT AND ORGANIZATION CHANGE<br>- OVERSEE EDUCATION AND TRAINING |
| QUALITY MANAGEMENT BOARD | - PLOT THE PROCESS<br>- ANALYSIS OF CAUSES<br>- MODIFY/CHANGE | - CHARTERED FOR ONE MAJOR PURPOSE<br>- COMPOSED OF "EXPERTS" WHO OWN THE PROCESS<br>- 5-8 PERMANENT MEMBERS<br>- WORK NORMALLY TAKES PRIORITY OVER OTHER WORK<br>- PERFORMANCE FEEDER REPORT (PROVIDES FEEDBACK TO SUPERVISORS)<br>- PROGRESS REPORTS PROVIDED |
| PROCESS ACTION TEAM | - DATA COLLECTION AND COLLATION<br>- FEEDBACK TO QUALITY MANAGEMENT BOARD | - CHARTERED BY QUALITY MANAGEMENT BOARD<br>- COMPOSED OF PROCESS OPERATORS<br>- DEVELOP BASELINES MEASURES AND DATA COLLECTION METHODOLOGY<br>- RESOLVE PROBLEMS/SPECIAL CAUSES<br>- PLOT AND REVIEW DATA<br>- RECOMMEND CHANGES/MODIFICATIONS TO QUALITY MANAGEMENT BOARD |

Figure 12

According to Drucker [5:199], making work productive requires four separate activities. These include:

> First, it requires *analysis*. We have to know the specific operations needed for work, their sequence, and their requirements.
>
> But we also need *synthesis*. The individual operations have to be brought together into a *process* of production.
>
> Third, we need to build into the process the *control* of direction, of quality and quantity, of standards,and of exceptions.
>
> Fourth, the appropriate *tools* have to be provided.

Figure 13 is an example of this structure and the potential cross-functional relationship between TQM and the command strategies, goals and objectives.

This structure involves both horizontal and vertical lines of communication. Quality Management Boards (QMBs) are permanent, hierarchically linked, cross-functional teams, designated by top NAVAIR management (Executive Steering Committee members) to evaluate targeted process improvements. QMB members include management and one or more sub-level managers or staff with expertise in the targeted process areas. Process Action Teams (PATs) are comprised of staff members involved and knowledgeable in the process being evaluated by the QMB. The PAT researches, collects and summarizes baseline data on process performance for the QMB.

In the following example, a QMB is assigned by the Executive Steering Committee to evaluate a given corporate strategy. From this, cross-functional QMBs and PATs are established to investigate the process performance within the strategy's supporting goals and objectives. The ⊗ highlighted in Figure 13 represents the organizational "link" to help foster vertical and horizontal communications and cooperation [8:vii, 5-6].

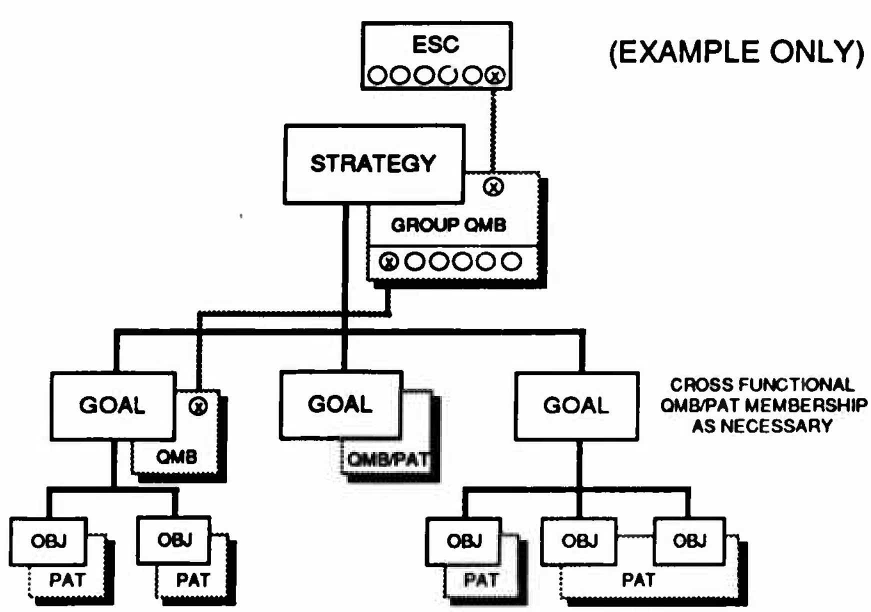


Figure 13

The evaluation of the processes involved in working towards achieving stated strategies, goals and objectives is quite rigorous. Under this approach, major organizational goals are identified and analysis of the process variables affecting the achievement of them is conducted. Asking intelligent questions relative to potential process improvements, probability of problem resolution, measurability and quantification, visibility/importance and timeliness of any required process change is imperative. Process evaluation conducted throughout and across strategies, goals and objectives, whether quantitative or qualitative, is a superb mechanism for identifying and understanding where the organization is at any given point in time and where it needs to go. Ongoing objective evaluation and change is inherent in this feedback mechanism. Top executives and managers throughout the command, by this means, are kept abreast of process problems/successes.

Performance Measurement and Tracking. Key elements in a successful performance feedback system include performance indicators and associated measurement criteria. Although often complex and difficult to develop, performance indicators with reasonable measurement criteria are critical for enabling the organization to improve its strategic planning position. Performance indicators and measures vary with corporate level and functional activity. At each successively lower level in the command, performance indicators and measures cover more specific operations and tasks. Executives and managers should be responsible for the performance criteria at their respective levels.

NAVAIR executives and managers carefully identified those performance indicators and measures best achieving targeted goals and objectives. Performance indicator monitoring is currently performed at various levels within the command and is done so by several techniques. Automated performance indicator tracking systems are utilized by many offices. NAVAIR's ultimate goal, with respect to automated performance monitoring and control systems, is to have a command-wide Executive Management Information System (EIS) designed to provide COMNAVAIR, other executives and managers at all levels with strategic planning data useful for their needs.

The design and implementation of an EIS for a complex organization such as NAVAIR involves many elements. Consideration must be given to a variety of concerns such as target users, their physical location, existing information requirements, future requirements, current and future system capabilitiy, flexibility, efficiency, effectivity, growth potential, timeliness, complexity, etc. The factors to be considered are voluminous. In general, however, the capability to analyze aggregated data is important to the command's needs. The ability to "roll up" information from the business plans to the strategies and analyze and present such data is a clear need identified by various managers throughout the command. The key is to design a system capable of integrating a multitude of information to be shared by all managers.

Evaluation of the development of a command-wide management information system is currently underway.

## CONCLUSIONS/SUMMARY

NAVAIR's success will be measured this fall when the evaluation of command strategies occurs. It will be during this time that the effectiveness of the strategic planning process will be determined and the quality of selected alternatives evaluated. Until then however, the author believes it fair to assume that NAVAIR has done an exceptional job in its initial attempt to formalize a strategic planning process. Given the highly diversified and complex nature of the organization, the creation of a dynamic planning system characterized by teamwork, commitment, cross-functional interdependency, human resource-work process integration and ongoing communication represents a significant milestone surpassed.

The practical effect of all the hard work is that each employee from clerical to theoretical aerospace researcher has a focused work plan that supports in general and specific, the direction promulgated by the NAVAIR Corporate Plan. By fine-tuning the command's organizational purpose and more clearly articulating its mission, NAVAIR's 48,000 employees are now working towards achieving the same goals and objectives which creates a more efficient and effective organization capable of dealing with the challenges of the future. Application of command resources towards the same goals and objectives enables challenges such as increasing technological complexity, diminishing resources, fleet support, product and service quality and quality of life to be dealt with in a more consistent, structured manner.

Only time will tell, but NAVAIR's efforts should not go unnoticed. The dedication and commitment demonstrated by COMNAVAIR and other top executives and managers to better position the command for the future is to be commended.

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# TECHNOLOGY TRANSFER GUIDELINES FOR PROGRAM MANAGERS

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## ABSTRACT

Dual sourcing to attain competitive production sources is a major focus within the weapon system acquisition process. A critical component of a successful dual source program is a comprehensive technology transfer effort which encompasses all program office, initial source, and second source activities required to qualify a second production source.

There are several objectives which would lead a program manager to decide to pursue a dual source strategy, such as reducing or controlling costs, improving quality, reducing program risk, expanding the mobilization base, enhancing schedule, and ensuring supply.

The selected strategy of transferring technology depends upon the objective of a dual source strategy, the type and availability of technical data to be transferred, the weapon system complexity, anticipated second source support required of the initial source, manufacturing complexity and life cycle phase of the weapon system. Several strategies have been employed to accomplish technology transfer including: Technical Data Package (TDP), leader-follower, contractor teaming and licensing.

The technology transfer process itself includes four fundamental activities:

- Transfer of technical data to the second source
- Provision of engineering, material and training assistance to the second source
- Development of the second source production line
- Qualification of the second source as a capable producer.

These activities are affected by the technology transfer strategy selected. Transferring data and providing assistance involve initial contractor support in leader-follower, contractor teaming and licensing. In a TDP method, the government would ensure technical assistance and guidance is provided to the second source in interpreting the data package. For all methods, government and initial contractor involvement in development of the second source production line and qualification of the second source are dependent upon the complexity of the weapon system and manufacturing processes.

In order for the four fundamental activities to be effective, they must be actively managed. Several key management functions include:

- Developing a technology transfer plan (TTP) that serves as a guiding document for monitoring the dual source effort and that describes the activities and responsibilities of the government and the contractors
- Establishing a dual source management structure to control the technology transfer effort
- Defining contractor agreements whch permit both contractors access to each other's facility and the transfer of company-sensitive data
- Providing incentives to the contractors to enhance the timeliness and completeness of technology transfer
- Controlling the configuration of the dual source effort to ensure complete, up-to-date data are available to both contractors and the government
- Defining milestones to measure the second source's progress in becoming a qualified production source.

A TTP is comprised of the aforementioned planning milestones. The level of detail in a TTP depends upon the maturity of the program. As a program matures, additional detail is incorporated in the TTP. The plan serves as the guiding document for all program personnel involved with the dual source effort. It also is the basis for associated plans such as configuration management, test, and qualification.

## INTRODUCTION

Successful technology transfer requires the development of an integrated plan that reflects a logical flow from government dual source objectives through technology transfer from an initial source to a second source to qualification of the second source as a capable producer.[1]

There are four technology transfer strategies predominantly used by the government. A TDP approach involves the development and validation of a complete set of engineering drawings and delivery of those drawings to a second production source. An adequate package contains the complete system specification, complete engineering drawings, tooling and test equipment drawings, acceptance test procedures, and process instructions.

Two strategies used primarily when the weapon system is still in development are leader-follower and contractor teaming. Leader-follower involves direct contractor-to-contractor transfer of all technical data that is required to establish a second production source. The system developer (leader) provides training, technical assistance, material support, vendor qualification, and detailed manufacturing support to the second source (follower). Contractor teaming is the formation of a team by two contractors for full scale development of a system. Both contractors fulfill specific and distinct design responsibilities and then exchange each other's production technology.

Licensing involves the development of a second source by the system developer. The system developer is directly compensated for the technology transfer effort and receives a royalty fee for every item produced by the second source (licensee).[2]

Selection of a technology transfer strategy is inherently linked to anticipated technology transer activities. For example, when patent protections are employed by the initial source, a licensing strategy is preferred. Technology transfer encompasses several fundamental activities including transferring technical data, providing assistance, developing the second source production line and qualifying the second source.

The approach to accomplishing technology transfer and achieving milestones is documented in a TTP. A thorough TTP includes the following elements which are discussed in greater detail in the remainder of this paper:

- Data to be transferred
- Anticipated technical support
- Second source production planning
- Second source qualification requirements
- Dual source program management structure
- Contractor and government agreements
- Incentives
- Configuration management procedures
- Demonstration milestones
- Contract vehicles.

## TRANSFERRING TECHNOLOGY

### TRANSFERRING DATA

The level and format of technical data to be transferred are directly related to the desired level of configuration control, the required level of qualification, and program maturity. The data elements to be transferred, the format of the data and the validation of that data should be decided early in the process.

#### Key Data Elements

The second source must be provided sufficient technical data to allow fabrication of end items and accomplishment of production qualification. Regardless of the technology transfer strategy, key technical data elements to be transferred include:

- Specifications
- Technical drawings
- Tooling and test equipment drawings
- In-process test procedures
- Acceptance test procedures
- Numerical control tapes
- Referenced standards
- Manufacturing work instructions
- Contractor training manuals
- Make/buy plans.

Under a TDP approach, these elements comprise a "complete" technical data package. Under a leader-follower or teaming approach, these elements are the initial technical data that are further supplemented by technical assistance.

#### Data Formatting

The evolution of computer-aided design and data management has introduced a wide variety of media for formatting and storing technical data. Hard copy refers to traditional paper documents. Strict reliance on hard copy engineering drawings is neither efficient nor desired. Alternate media for data storage include microfilm and magnetic. Microfilm copies of hard copy documents are usually in the form of aperture cards. This method facilitates storage and retrieval of information. Magnetic refers to computer-aided design/computer-aided manufacturing (CAD/CAM) software packages and their file storage capabilities. Data stored in this manner can be transferred directly from the system developer to the second source, assuming compatible CAD/CAM systems. Hence, magnetic storage provides the quickest, easiest, and least expensive means of data transfer.

#### Validating Technical Data

The level of program office involvement in data validation is directly related to the technology transfer strategy. For example, the government may play a limited role under a leader-follower approach while a more intense government validation effort would be required under a TDP approach. The validation of technical data can be viewed as a four-tiered effort that encompasses the following steps:[3]

- Inventory and format -- Audit of all drawings, specifications, and designs to establish that complete and properly formatted documentation exists for all component parts, assemblies, and end items
- Physical Configuration Audit (PCA) -- Government examination, testing, and comparison of the equipment against the TDP
- Demonstration -- On-site audit of the developer's manufacturing methods (including assembly, tooling, and test procedures). In addition, the developer conducts the actual assembly, inspection, and test of several sets of randomly selected parts and assemblies
- Hardware Build -- Government may build validation units in a government-owned and operated facility.

### PROVIDING TECHNICAL SUPPORT

A successful technology transfer effort may require technical support over and above the transfer of data. Technical support includes:

- Training and engineering assistance
- Material support and long lead
- Provision of kit items and training aids
- Test support.

Support in any of the areas may be required from the initial source or from the program office. Technical support requirements are coordinated through the dual source management structure.

#### Training and Assistance

Training programs and engineering assistance are provided to the second source for system-specific manufacturing, assembly, and test procedures. Training and assistance are directed toward those areas where the second source may be deficient. Representative areas include:

- Material inspection techniques and procedures
- Special test procedures and equipment usage
- Fabrication and assembly procedures

- Critical process fabrication techniques and procedures
- Tooling and test equipment calibration procedures
- Clarification of the system drawings or engineering data
- Provision of additional engineering data such as product reliability and manufacturing lessons learned.

Training and assistance are provided to accelerate the development of the second source's engineering and manufacturing capabilities. This assistance also reduces the risk of second source mistakes due to misinterpretation of data or missing data elements. Training and assistance are provided by the initial source under a leader-follower or teaming strategy. When additional assistance is required under a TDP strategy, it is provided by the government or the initial source under a separate engineering services contract.

Material Support and Long Lead

Support in the areas of long lead material acquisition, vendor base guidelines, inventory control procedures and quality assurance provisions are required to reduce second source development time and risk. The program office determines long lead material support requirements through the following steps:

- Determine a general second source fabrication schedule based upon the qualification and initial production requirements (initial source production flow times are used prior to selection of a second source)
- Identify material need dates based on the fabrication schedule
- Identify order dates based on current material lead times and the need dates.

Kit Items and Training Aids

Kit items and training aids are provided to the second source to reduce qualification lead times and manufacturing risks. End item kits contain all parts, subassemblies, and assemblies that comprise the final end item. Kits are used to validate the technical data against actual hardware, to demonstrate second source process and assembly capability, and to accelerate production line development. Similarly, shop models and training aids provide the second source engineering team with mock-up hardware that can be used to validate data, develop test procedures, and assess process requirements.

Test Support

Test support is provided on programs where the initial source retains design agent responsibility or maintains test data and failure reporting systems. In those cases, the initial source serves as a logical complement to the program office engineering and test staff. Assistance is provided for both factory tests and operational tests of the second source equipment.

Technical support reduces the risks associated with inadequate data, ensures that lessons learned by the initial source are transmitted to the second source, and accelerates the development of the second source's manufacturing capability in an orderly fashion. The primary intent of technical support is to ensure the timely qualification of the second source. The provision of long lead material and kit items is particularly useful in developing the second source production line.

SECOND SOURCE PRODUCTION LINE

Critical activities associated with establishing the second source production line include developing the manufacturing plan, procuring and/or fabricating tooling and test equipment, and fabricating the qualification and the directed buys.

Manufacturing Plan

The initial step in establishing the second source production line is the preparation of a manufacturing plan by the second source. The plan is based on the manufacturing information in the TDP, the master production schedule, existing facilities and equipment, and preliminary make/buy plans. The plan is prepared in accordance with MIL-STD-1528A, "Manufacturing Management Program," September 1986, and contains the following critical elements:

- Manufacturing capability
- Capital and facilities requirements
- Special tooling and test equipment
- Manpower forecasts.

Tooling and Test Equipment Fabrication

Initial source or program office assistance in procuring or fabricating second source tooling and test equipment greatly enhances the second source transition to production. Early provision of tooling requirements to the second source is required to allow for the long lead times related to the acquisition or fabrication of special tooling and special test equipment (ST/STE). To accomplish this requirement, an itemized list of all required tooling, test equipment, and specifications should be supplied to the second source as part of the TDP or as supplemental data.

The itemized list should include all fabrication, testing, and qualification requirements, the associated lead times and means of acquiring each piece of equipment, and the rate capacity of the equipment. Additional data includes copies of the initial source's tooling and test equipment data packages, potential sources, clarification of specifications, drawings, and operating instructions.

ST/STE usually is the pacing item of the second source production line. Thus, timely provision of ST/STE data is integral to the successful achievement of the qualification schedule.

Production Planning

Simultaneous with the procurement or fabrication of ST/STE, the second source initiates its detailed production planning. This effort includes the following activities:

- Perform process analyses and trade-off studies
- Prepare line-of-balance and process control plans
- Prepare detailed facility and plant layouts
- Prepare manufacturing work instructions
- Develop standards and work measurement processes
- Prepare process sheets and inspection instructions
- Define and implement quality assurance procedures and systems.

Materials Acquisition

Concurrent with in-plant activities, the second source also establishes a subcontractor and supplier base. There are three sources of suppliers:

- Current suppliers to the initial source
- New suppliers for initial source buy items
- New suppliers for initial source make items.

Using new suppliers is the preferred approach; however, for high value or specification controlled items, the program office may elect to have both primes buy from the same vendors. When the second source employs current initial source suppliers, it informs the suppliers of the dual source weapon system program and provides notification that they are authorized to use special tooling and test equipment at the supplier's plant. The initial and second sources then determine the details of subcontract administration of and material ordering from the suppliers. An agreement in this area is particularly useful for high value or long lead subsystems where economics of ordering are desired and the production split is not known prior to placing the subcontract. Agreements also are developed that address how shortages are to be distributed between the two primes, should the supplier encounter delivery problems. The details of subcontract administration are documented in a memorandum of agreement and are coordinated through the dual source management structure.

Kit Assembly

Recent programs have employed end item kits to accelerate development of the second source production line while providing incremental demonstrations of second source capability. Kits are composed of all assemblies, subsystems, parts, and components that are required to assemble the final item.

The Qualification Buy

The qualification buy is a relatively small quantity to support the second source's qualification testing requirements and to develop the second source's production capability. To accomplish the buy, the second source installs all tooling and test equipment. The government or initial source provides on-site technical assistance during fabrication of the second source qualification hardware. Any changes in the manufacturing processes or design to accommodate the second source's methods are implemented and demonstrated during end item fabrication.

The Directed Buy

The second source's first production lot award usually is directed by the government. The objective of the directed buy is to avoid a production break at the second source facility while the qualification hardware undergoes final testing. The directed buy is limited to minimize the risk of not meeting operational requirements. This measure also allows the second source to ramp-up its production line to support future production rate requirements. It requires the second source to utilize its own vendor base and manufacturing techniques prior to competitive awards to ensure that qualified production units can be fabricated.

QUALIFYING THE SECOND SOURCE

The purpose of the qualification phase is to have the second source demonstrate ability to manufacture hardware that conforms to the TDP including all specifications. This phase involves hardware fabrication, assembly, and testing to determine TDP compliance by the second source. The testing phase involves a duplication of initial source production qualification tests and limited performance testing. The components of an integrated second source qualification program include:

- Component verification -- The inspection, testing, and analysis of components purchased or manufactured by the second source. The purpose of component verification is to demonstrate the second source's ability to purchase or manufacture components that meet specifications

- Process verification -- Demonstration by the second source that its materials, tooling, equipment, workmanship, and associated paperwork are equivalent to those established by the initial source and identified in the TDP

- Acceptance tests -- Testing of the second source's full-up system. The purpose of these tests is to demonstrate under controlled conditions that the system produced by the second source is functionally identical to the system produced by the initial source

- PCA -- Performed on production representative items. The purpose of the PCA is to confirm that the "as-built" production configuration of the hardware produced by the second source conforms to the system specifications and drawings.

## MANAGING THE PROCESS

DEVELOPING A TECHNOLOGY TRANSFER PLAN

A TTP, should be prepared prior to the preparation of the statement of work. It then serves as the technical baseline for contract provisions. The level of detail of the plan depends upon the maturity of the weapon system. The plan serves as the guiding document for all program personnel associated with the technology transfer effort. As such, it functions as the cornerstone for more detailed, subordinate plans such as configuration management, production, manufacturing and logistic support plans. A basic outline of a TTP would include the purpose of the TTP and the dual source objectives, a description of the weapon system, an overview of the acquisition strategy, initial and second source make/buy plans, management structure, initial and second source responsibilities, configuration management, data transfer, and establishment of the second source production line.

ESTABLISHING THE MANAGEMENT STRUCTURE

To ensure program objectives are met, the government must retain overall management authority for the dual source effort. Once the decision to dual source has been made, the program manager should appoint a dual source program manager within the program office to monitor, manage, and execute the program. A dual source program staff may be organized either by function or activity. A functional organization works well either when the overall program is a self-supporting entity staffed with sufficient personnel who are capable of carrying out the dual source requirements or when the program office has a clearly defined dual source cadre with the responsibility and authority to manage and work with matrixed, functional support. An activity-oriented organization may be more effective when dual sourcing a technically complex or schedule sensitive program.

A simple contractual requirement to have one contractor transfer technology to another does not ensure that such a transfer will occur in a timely, efficient manner. To facilitate the process a technology transfer working group (TTWG) can be used.

The TTWG, composed of functional and management representatives of the government and both contractors, is responsible for coordinating and facilitating technology transfer between the two contractors, whether the transfer is to be a bilateral or unilateral exchange. It conducts technical reviews and technical interchange meetings to ensure that program performance and control are maintained at acceptable levels. The program office may request the contractors to establish or participate on a TTWG in order to effectively achieve dual source objectives. The requirements for a TTWG should be addressed in the contractor agreements and the TTP.

DEFINING CONTRACTOR AGREEMENTS

Technology transfer is implemented through government contractual provisions with both contractors and through contractor-to-contractor agreements. The contractor agreements normally are developed and negotiated by the contractors; however, the program office must ensure that the contractor agreements support the objectives of the dual source program.

A contractor agreement may facilitate dual sourcing by establishing the basis for exchange of data between contractors and defining the terms and conditions of the data exchange. Based on the statement of work and dual source objectives, an agreement details the guidelines and restrictions necessary to effect complete transfer of proprietary or company-sensitive data and may make provisions which allow each of the contractors to have access to each other's facility. Roles and responsibilities of each contractor during the technology transfer phase may be defined.

PROVIDING INCENTIVES

One of the most controversial areas of technology transfer is the development and application of effective incentives. Prior programs have employed incentives to enhance technology transfer; however, the effectiveness of those incentives is difficult to assess. The fundamental issue is that there is no incentive large enough to compensate an initial source for lost production volume due to dual sourcing.

The key component of an effective incentive is a clear understanding of each contractor's motivations. Often the focus is purely financial such as award fees; however, a financial award may mean little to a contractor who is faced with a large potential loss of production volume. Alternately, a contractor may be more effectively motivated by elements such as cash flow, production volume or production stability.

Another financial incentive approach is the use of penalties or awards based upon the attainment of specific milestones. For example, initial source progress payments may be tied to key second source milestones. Application of this type of incentive requires that the initial source be contractually responsible for key technology transfer efforts.

On new-start programs, the program office can require the system developer to qualify a second source as part of the FSD contract. This approach includes the delivery of initial production hardware fabricated by the second source. The initial source becomes financially responsible for delivery of those hardware items. Failure of the second source to qualify implies that the initial source will produce and deliver the contracted items at no additional cost to the government.

Prior programs have employed a guaranteed minimum split as a technology transfer incentive. That is, a portion of the competitive buy is committed to the initial source based upon timely completion of technology transfer. This incentive builds upon the contractor's desire for production volume and a stable production base.

### CONTROLLING THE CONFIGURATION

One of the most often cited concerns over dual sourcing is the deployment of multiple variants of an end item. Prior dual source programs have avoided this complication through an integrated technology transfer program and diligent configuration management.

Current DoD guidance does not explicitly provide for managing a weapon system's configuration in a dual source environment. It is the responsibility of the program manager to establish configuration control procedures that will satisfy all program objectives, including dual sourcing. When developing a configuration management approach, the purpose of dual sourcing and the type of equipment involved should be the primary drivers.

The technology transfer strategy and the level of configuration control required by the program office jointly determine the relationship between the initial and the second sources. Under a teaming or leader-follower approach, the lead contractor (or the team if it is a joint venture) is responsible for the overall design and performance of the weapon system. As the design agent, that contractor is responsible for ensuring all relevant technology (including changes as they are approved) is communicated to and implemented by the second source. Under a TDP approach, where there is no direct technical interchange between the two contractors, it is the responsibility of the program office to ensure an adequate drawing package and associated changes are distributed to the second source in a timely manner.

It is essential that the configuration management approach be in place from the outset of a dual source effort, particularly with direct contractor-to-contractor technology transfer. The program office defines configuration objectives and their relation to overall program and dual sourcing goals, and explicitly conveys them to the contractor. As part of a request for proposal, configuration management requirements are presented in terms of objectives to be achieved and tied to specific program milestones. The initial source then responds with a detailed configuration management plan that accommodates the unique aspects of its internal configuration management system, the second source's system, and how the two plans interface. In addition, the plan describes how baselines are to be managed.

### DEFINING MILESTONES

Interim program milestones are crucial to assessing technology transfer progress and to establishing confidence in the second source's ability to produce the end item. Careful definition of interim milestones provides the program office with a mechanism for managing and reducing risk. Potential milestones include:

- Control and validation of the data package
- Critical process demonstrations
- Subsystem and component verification and interchangeability demonstrations
- Kit assembly and checkout
- Fabrication of qualification units
- Qualification testing
- Directed buy
- PCA.

### SELECTING A CONTRACT VEHICLE

Contractual requirements for the initial and second sources are complementary to ensure a cohesive technology transfer effort. Once the statements of work are defined, the contract type is developed based upon risk, schedule urgency, and potential incentives.

The contract type varies depending upon the technology transfer approach and the maturity of the program. For new-start programs, technology transfer requirements are tied to the initial source's FSD contract. This provides the program office with the leverage of the FSD and production programs. For more mature programs, the initial source effort is tied to that contract effort that has the greatest unexpended financial balance.

If the second source is to be a prime contractor to the government, the contract type and the use of options must be assessed. Key elements that are considered include maturity of the system, quality of available data, and technical complexity. Incentives may be incorporated to enhance schedule acceleration and/or cost control. Options also are incorporated for a limited production buy. This approach is helpful in simplifying contracting requirements and in providing insights into an offeror's production pricing strategy during selection of a second source.

## CONCLUSION

Once the decision has been made to dual source a program, thorough planning will enhance successful technology transfer. The reasons for pursuing a dual source strategy are varied - from cutting costs to ensuring supply. Strategies currently used to dual source include TDP, leader-follower, contractor teaming and licensing. The actual technology transfer process involves the exchange or transfer of data, the provision of support, establishment of the second source production line and qualification of the second source. The management of that process involves developing a technology transfer plan, establishing a dual source management structure, obtaining contractor agreements, devising incentives, managing the configuration, defining measurable milestones, and choosing the contracting strategy.

The dual source development process should be thoroughly planned in order to ensure the majority of potential issues have been addressed and an effective implementation plan has been developed.

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# PRICING AND COST ESTIMATING

# COST RECOVERY OF INDEPENDENT RESEARCH AND DEVELOPMENT AND BID AND PROPOSAL

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## ABSTRACT

According to the Federal Acquisition Regulations (FAR Section 31.205-18), Independent Research and Development (IR&D) is the technical effort independently initiated and sponsored by a contractor in support of its own product development. It is not required in the performance of a government contract or grant. Bid and Proposal (B&P) expenses are costs incurred in preparing, submitting, and supporting bids and proposals on both potential government and non-government contracts.

The current legislation covering IR&D, Public Law 91-441, the DoD Appropriation/Authorization Act of 1971, was an outgrowth of extensive dialogue regarding IR&D policy during the 1960's.

About 10% or $5 billion of an estimated $50 billion in IR&D/B&P expenditures are spent by companies doing business with the federal government. Two of the predominantly used methods for cost recovery of the $5 billion are: (1) the Advance Agreement Method and (2) the Formula Method. The Advance Agreement Method is used when the contractor's previous year recovery from government agencies exceeds $4.4M.

A third and less frequently used method is a Non-Mandatory Advance Agreement Method which, like the Formula Method would be used only if the IR&D/B&P recovery from government agencies was below $4.4M.

The overall process of these methods is discussed in detail on the attached pages.

## INTRODUCTION

Independent Research and Development and Bid and Proposal, referred to as IR&D/B&P, are necessary costs of doing business. Since products have to be developed and then marketed, contractors either recover the cost from commercial or government customers through inclusion in product pricing or through profit. This paper will cover the process by which the federal government, primarily DoD, participates in paying a share of this cost.

According to the Federal Acquisition Regulations (FAR Section 31.205-18), Independent Research and Development (IR&D) is the technical effort independently initiated and sponsored by a contractor in support of its own product development. It is not required in the performance of a government contract or grant. By definition IR&D ranges from basic and applied research to development and also includes system and concept formulation studies. Bid and Proposal (B&P) expenses are costs incurred in preparing, submitting, and supporting bids and proposals on both potential government and non-government contracts. There is often a gray area between a company's IR&D activities and their B&P activities since many times B&P efforts require knowledge gained through IR&D for submission of successful technical proposals. The potential for overlap between the two activities occurs since some IR&D costs are in direct support of potential B&P efforts and could be charged to either account.

### Background

IR&D costs have been reimbursable in some form since 1940. The current legislation covering IR&D, Public Law 91-441, the DoD Appropriation/

Authorization Act of 1971, was an outgrowth of extensive dialogue regarding IR&D policy during the 1960's. Many issues were being raised on the value of much of the IR&D to the federal government. The Government was questioning whether it should pay for research that supports commercial product development only. Also, questions were raised concerning whether there was duplication of funding by giving the contractors money for IR&D and then again for research on a contract.

This debate resulted in restrictions in the 1971 Public Law 91-441. (8) This law permits DoD to reimburse contractors for IR&D/B&P costs as an overhead expense. Section 203(a) of the law requires that IR&D/B&P costs must have a "potential relationship to a military function or operation" to be allowable. This requirement is commonly referred to as PMR.

## Methods of Cost Recovery

When considering the industry as a whole, about 10% or $5 billion of an estimated $50 billion in corporately funded IR&D expenditures are spent by companies doing business with the federal government. Two of the predominantly used methods for cost recovery of the $5 billion are: (1) the Advance Agreement Method and (2) the Formula Method. The use of a particular method depends upon the contractor's amount of recovery from government agencies in its preceding fiscal year. The greatest amount of dollars are recovered through the Advance Agreement Method. This method is used when the contractor's previous year recovery from government agencies exceeds $4.4M. The contractor must submit technical plans and cost proposals for planned IR&D/B&P which form the basis for a negotiation of cost recovery. The negotiation results in a ceiling dollar amount which is added to the G&A expense pool for development of a G&A rate.

The Formula Method ranks second in cost recovery for IR&D/B&P costs. This method is utilized if the contractor's total IR&D/B&P recovery from government agencies in the preceding fiscal year was less than $4.4M. Once a ceiling amount is set by formula, recovery of that amount is through G&A as described above.

A third and less frequently used method is a Non-Mandatory Advance Agreement Method which, like the Formula Method would be used only if the IR&D/B&P recovery from government agencies was below $4.4M. As a general rule, this method is used by small and fast growing companies when application of the formula may be inequitable.

## Overall Process

The overall process of the three IR&D and B&P cost recovery methods is depicted in Table I, and each of these methods is discussed in detail in the remainder of this paper.

## Mandatory Advance Agreements

The majority of DoD cost recovery for IR&D/B&P is through the mandatory advance agreement. Some materials for reference include FAR 31.205-18, FAR 42.10, SECNAV Instruction 3900-40B, and DoD Instruction 3204.1. Listed below is a step by step procedure applied to Mandatory Advance Agreements and some problems related to the process:

Companies that have received IR&D and B&P payments in excess of $4.4M from government agencies in their preceding fiscal year, either as a prime or a subcontractor must negotiate advance agreements. Negotiations are conducted at the corporate level once this initial threshold is met. Separate ceilings may be negotiated at the division level if the corporate level is met and recovered IR&D and B&P costs exceed $550,000 for the division.

Prior to the start of its fiscal year, the contractor submits a cost proposal to the lead service Tri-Service Negotiator (TSN). The lead assignment is determined by which military service has the greatest volume of business with the contractor.

At the same time, a mini-plan listing and briefing descriptions of IR&D projects to be performed is sent to the lead service assigned technical evaluation responsibility. The purpose is to allow for a determination of potential relationship to a military function or operation (PMR) of each project in accordance with Public Law 91-441, Section 203. These determinations are provided to the responsible TSN. B&P listings are provided directly to the TSN for PMR determination.

No later than 90 days after the start of its fiscal year, the contractor must distribute a technical plan fully describing the individual projects comprising its IR&D program to evaluating activities designated by the lead service technical evaluation office. The purpose is to provide a determination of technical quality, as required by the law for consideration in the negotiation process. Results are provided to the TSN for use in negotiations. Companies are provided with appropriate feedback on their ratings as well.

The TSN negotiates the entire cost ceilings of IR&D and B&P. This includes the contractor's allowable and recoverable IR&D and B&P from DoD, other government agencies, and commercial contractors. Determination of the ceiling is through application of rules set forth in FAR 42.1006 and involves comparison of the current year proposed IR&D and B&P programs. Although called advance agreements, the agreements are usually not actually negotiated until well into a company's fiscal year.

DoD's share is not separately negotiated by the TSN. Once the ceiling is negotiated, it is added to the G&A cost base and rates are determined. The DoD share is the amount recovered through G&A from contracts performed for DoD.

It is the contractor's responsibility to request an advance agreement. If a company fails to initiate negotiations, no cost will be allowable for IR&D and B&P. If no agreement is reached (which happens very rarely) the contractor can be paid much less than what they would have been entitled to had an agreement been reached.

The Industry side argues that long and irrelevant negotiations delay the IR&D and B&P advance agreement process. They also suggest that the technically superior projects do not receive due credit at the negotiation table. The military services see the technical review process as an opportunity to press contractors to support their services' current program priorities.

Formula

This method is used for companies which recovered less than $4.4 million IR&D costs from government agencies in their preceding fiscal year. The formula is described in detail in FAR 31.205-18 (c) (2). Under the formula method, generally the following apply:

- The contractor must have at least three years of historical data. If they don't then they can use the non-mandatory advanced agreement which is explained later.

- The contractor's IR&D and B&P recovery in the preceding fiscal year from government agencies was less than $4.4 million.

- No technical plan is submitted and therefore PMR is not an issue.

- It is applicable equally to large and small contractors.

- The contractor may get assistance from their ACO in applying and calculating the formula. An example of how the formula works is shown on Table II.

Non-Mandatory Advance Agreements

Generally, the non-mandatory agreement is considered a relief from the formula when inequities result because (1) the contractor's IR&D and B&P expenses are in excess of the amounts considered reasonable by the formula or (2) the contractor incurred little or no IR&D and B&P expenses in prior years and had no basis for the formula. This is an especially relevant avenue for small and fast growing companies. A detailed description of the non-mandatory agreement is set forth in Defense Logistics Agency Manual (DLAM) 8105.1, Ch. 6, 31.109-4(i). Some of the general principles that apply to these agreements are:

- The contractor's preceding fiscal year for IR&D and B&P recovery from government agencies was less than $4.4 million.

- Inclusion of PMR in the technical plan adds favorably to the acceptance of costs proposed.

- There are no technical quality ratings but there is a technical plan which is submitted to the contractor's cognizant ACO. Government technical review is requested as necessary.

- There can be less than 3 years of historical cost data but there usually is more than one.

- They are applicable equally for large and small contractors.

- The TSN offices rarely get involved in these non-mandatory agreements. The cognizant ACO negotiates nearly all of them. The contractor may get assistance from their ACO concerning application of the non-mandatory advance agreements.

- As in a mandatory advance agreement the contractor should submit cost proposals and technical plans within 90 days after the start of the contractor's fiscal year.

## CONCLUSION

Throughout its existence, the topic of IR&D has continued to be a subject of controversy. Of what value is IR&D to the federal government? Isn't the government duplicating payments to contractors by paying for IR&D and then R&D under a contract? Why does the IR&D require PMR in order for the government to reimburse the costs? Most all of these questions continue to exist in some fashion. DoD has attempted to reduce some of the ambiguity of the IR&D reimbursement process by the incorporation of more structured approaches: the mandatory advance agreement and formula as set forth in the FAR, and the non-mandatory advance agreement as set forth in the DLAM. The government needs industry's defense-related IR&D projects as much as industry needs government's participation in its IR&D costs. Since it continues to be an unavoidable cost of doing business which is borne by industry, it is likely that continued efforts will be made by DoD to clarify and simplify the process for fair and reasonable participation in industry's IR&D expenses.

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(3) FAR 42.10, "Negotiating Advance Agreement for Independent Research and Development/Bid and Proposal Costs," April 1985

(4) Secretary of the Navy (SECNAV) Instruction 3900-40B, "Policy and Assignment of Responsibilities for the Independent Research and Development Program," 1983

TABLE I

Contractors Requesting Recovery for IR&D/B&P

Receive > 4.4M

Mandatory Agreement

Three or more years of historical data

Submit mini-plan to Technical Evaluation Office

Submit technical plan to designated service activities for review

Submit cost proposal to Tri-Service Negotiator (TSN)

Negotiation of allowable $ Ceiling by TSN

Receive < 4.4M

Formula

Must have ≥ 3 years years of historical data

Apply formula, determine allowable IR&D/B&P, submit to DCAA

No negotiations held

Nonmandatory Agreement

May have < 3 years years of historical data

Submit cost proposal and technical plan to ACO (technical review optional)

Negotiation of allowable $ recovery by ACO

Contractor & DCAA include IR&D/B&P $ Ceiling in G&A Base to determine G&A rate

Contractor recovers DoD share of IR&D/B&P through G&A on DoD contracts

TABLE II

| | A<br>Sales | B<br>IR&D/B&P<br>Incurred | C<br>IR&D/B&P % Derived<br>From Ratio |
|---|---|---|---|
| 1986 | $ 500,000 | $30,000* | 6%* |
| 1987 | $1,000,000 | $20,000 | 2% |
| 1988 | $2,000,000 | $70,000* | 3.5%* |
| 1989 | $3,000,000 | | |

*Two highest

Historical Ratio 6% + 3.5% = 9.5% ÷ 2 = 4.75%

Average Annual Cost $30,000 + $70,000 = $100,000 ÷ 2 = $50,000

- Product
  4.75% x $3,000,000 = $142,500
- Ceiling
  120% x $50,000 = $60,000
- Floor
  80% x $50,000 = $40,000

How to determine the allowable amount of IR&D and B&P from this example:

The product ($142,500) shall be considered allowable if it does not exceed 120% of the average ($60,000).

The product ($142,500) shall be considered allowable if it is less than 80% of the average ($40,000).

In this example, since the product exceeds 120% of the average and the product is not below 80% of the average, the allowable IR&D is $60,000.

(5) Federal Acquisition Regulation (FAR) 31.205-18, "Independent Research and Development and Bid and Proposal Costs," September 1987

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# ESTIMATING SYSTEMS—THE NEW EMPHASIS

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## ABSTRACT

The 1980's have seen the effectiveness of contractor estimating systems seriously questioned. The General Accounting Office (GAO) reported to the House Subcommittee on Legislation and National Security that contract audit surveillance activities of contractors' estimating systems needed improvement. The Department of Defense (DoD) office of the Inspector General (IG) issued reports on DCAA's Evaluations of Contractor Cost Estimating Systems. The House Committee on Government Operations also issued its report, "Overpricing of Defense Contracts Is Extensive, Expensive and Avoidable".

In response to these and other inquiries, the last three years have seen a new regulatory emphasis on contractor estimating systems. The FAR and the DFARS have both been updated, placing new requirements on contractors, contracting officers, and DCAA auditors.

This paper discusses some of the issues relevant to parties interested in DoD procurement activities. In particular, what the FAR requires, why the DoD sees a need to update the DFARS, and what the new DFARS regulation requires. Care is taken to present the history of the regulatory process, examine the audit responsibilities of contracting officers and the DCAA, and discuss the responsibilities of contractors. Estimating system disclosure requirements and standards are defined for all contractors. Surveys of contractors have gathered information that provides a picture of the current status of estimating system implementation. Finally, some thoughts on contractors' use of software in their estimating systems are presented.

## INTRODUCTION

In March 1988, the Department of Defense (DoD) published its final rule on contractor cost estimating systems. This revision of the Defense Federal Acquisition Regulation Supplement (DFARS)(1) places new demands on DoD contractors, contracting officers, and auditors. It beefs up considerably the rather hazy Federal Acquisition Regulation (FAR)(2) coverage on estimating systems by stating in more specific terms what is required in an estimating system, by making clear that all DoD contractors are required to have estimating systems, and by providing thresholds for disclosure and review of large-company systems.

The DFARS defines "Estimating System" as a term used to describe a contractor's policies, procedures and practices for generating cost estimates which forecast costs based on information that is available at the time. It includes the organizational structure; established lines of authority, duties and responsibilities; internal controls and managerial reviews; flow of work, coordination, and communication; and estimating methods, techniques, accumulation of historical costs, and analyses used by a contractor to generate estimates of costs and other data included in proposals submitted in the expectation of receiving contract awards.

An estimating system should be consistent with and integrated with the contractor's related management systems, and should be subject to applicable financial control systems. To be considered adequate, a contractor's estimating system must be established, maintained, reliable, consistently applied, and must produce verifiable, supportable and documented cost estimates.

Effects of the rule will be widespread and significant. All contractors submitting cost or pricing data to DoD must have an estimating system that produces well-supported proposals forming an acceptable basis for negotiating fair and reasonable prices. A clause requiring this will be inserted in all solicitations and contracts to be awarded on the basis of certified cost or pricing data. In addition, the clause will require certain large contractors to disclose in writing their estimating systems to the contracting officer responsible for contract administration.

In this paper we will discuss the contracting environment and background that has fostered the new emphasis on estimating systems; the requirements of the DFARS regulation; the government review process; the results of a survey that provide some indication of the current status of estimating system implementation; and some thoughts on contractors' use of software in the estimating process.

## WHY THE NEW RULE?

The DFARS regulation on estimating systems, as we shall discuss in some depth later, is by no means a clear-cut cookbook approach; it stresses general guidelines rather than specific, detailed requirements. In contrast to previous government guidance, however, it can be considered a significant move toward regulating DoD government contractors' estimating methodologies.

The FAR guidance (which the DFARS rule supplements) has historically been even more general in nature, and directed primarily to the cognizant auditor rather than the contractor or contracting officer. Here is the current text of FAR 15.811, Estimating Systems:

"(a) The consistent preparation of proposals using an acceptable estimating system benefits both the Government and the contractor by increasing the accuracy and reliability of individual proposals. Cognizant audit activities, when it is appropriate to do so, shall establish and manage regular programs for reviewing selected contractors' estimating systems or methods, in order to (1) reduce the scope of reviews to be performed on individual proposals, (2) expedite the negotiation process, and (3) increase the reliability of proposals. The results of estimating system reviews shall be documented in survey reports.

(b) The auditor shall send a copy of the estimating system survey report and a copy of the official notice of corrective action required to each contracting office and contract administration office having substantial business with that contractor. Significant deficiencies not corrected by the contractor shall be a consideration in subsequent proposal analyses and negotiations.

(c) In determining the acceptability of a contractor's estimating system, the auditor should consider—

(1) The source data for estimates and the procedures for ensuring that the data are accurate, complete, and current;

(2) The documentation developed and maintained in support of the estimate;

(3) The assignment of responsibilities for originating, reviewing, and approving estimates;

(4) The procedures followed for developing estimates for direct and indirect cost elements;

(5) The extent of coordination and communication between organizational elements responsible for the estimate; and

(6) Management support, including estimate approval, establishment of controls, and training programs."

The FAR guidance applies to all government agencies, including both defense and civilian, while the DFARS applies only to defense agencies. The DFARS states that its coverage on estimating systems "provides, for the convenience of DoD activities, a consistent but more detailed and comprehensive treatment of estimating system policies and procedures than FAR 15.811." As yet, none of the other agencies who provide regulations to supplement FAR have issued guidance that would provide more detailed coverage on estimating systems as does the DFARS. Thus at this time civilian agencies are required only to follow the more general guidance outlined in the FAR.

Until DoD issued DFARS 215.811, defense agencies also were controlled only by the FAR rules. However, the Defense Contract Audit Agency (DCAA), in accordance with its FAR responsibilities as cognizant auditor, developed audit guidance for its auditors to use in reviews of estimating systems. This guidance was published in its Contract Audit Manual (CAM)(3), and was thus available to contractors as a source of information for establishing their estimating system, or for evaluating and refining their system in anticipation of audit review.

While somewhat helpful to contractors, the DCAA guidance did not have the force of regulation, and it was available to only those contractors with the knowledge and experience to know of its existence and availability. Also, because it was only "guidance", it was not implemented in the field with total uniformity. Some DCAA offices treated it as the gospel and followed it very closely, while others considered it a guideline subject to interpretation and adaptation based on the environment and circumstances of the individual application.

Another problem with the CAM guidance on estimating systems was that it changed over time and was apparently not always fully understood by field auditors. The guidance historically provided for joint team estimating system surveys under CAM 9-1100, Joint Team Surveys of Contractor Estimating Systems. This section stated "...provides guidance for survey of contractor estimating systems to be performed jointly by DCAA/contract administration teams under DAR 3-809(c)(4)(ii)."

Then in January 1982, DCAA issued its first guidance on "real time" reports. The idea here was to have auditors issue reports on estimating deficiencies as they found them during proposal reviews, instead of waiting for an estimating system survey to inform the contractor and contracting officer of the problem. As time went by, some DCAA auditors apparently assumed that real time reporting either eliminated or reduced the need for joint reviews. As a result, DCAA noted a decline in performance of joint team reviews. This was corrected by clarification guidance issued in May 1985.

It was about this time that the effectiveness of contractor estimating systems began to be seriously questioned. The General Accounting Office (GAO) reviewed a number of contractor plants and reported to the House Subcommittee on Legislation and National Security that contract audit surveillance activities of contractors' estimating systems needed improvement.(4) The GAO followed up with a full review of contractor estimating systems in 1986 and 1987 and concluded that despite the reliance placed on cost estimating systems by contracting officers, contractors were not being required to maintain adequate estimating systems. Frank C. Conahan, Director, National Security and International Affairs Division of GAO, testified before the subcommittee(5) that existing regulations did not contain the standards needed to judge contractor estimating systems. In a June 3, 1987, letter to the Secretary of Defense, Mr. Conahan recommended that the Secretary direct DoD personnel to assemble and refine standards which clearly define what constitutes an acceptable system.

In the meantime, the DoD Inspector General was also active in the estimating system arena. In April 1986 and May 1987 the DoD IG issued reports on "DCAA's Evaluations of Contractor Cost Estimating Systems."(6) Some of the recommendations:

> To require joint estimating system reviews and budget preparation and execution reviews be performed a minimum of every three years

> To have auditors recommend written estimating systems for contractors with substantial government business.

> To include in DCAA guidance provisions for recommending disapproval of contractors' estimating systems when joint, follow-up, and/or real time reviews disclose significant reported deficiencies have not been corrected.

The House Committee on Government Operations also issued its report, "Overpricing of Defense Contracts Is Extensive, Expensive and Avoidable."(7) Two of the recommendations in the report were aimed at DCAA's coverage of estimating systems:

> To require DCAA to establish a program for carrying out periodic, in-depth reviews of contractors' estimating systems.

> To establish criteria for determining what constitutes an adequate cost estimating system.

What caused all these government entities—the DCAA, the DoD IG, the GAO, and Congress itself, to pay so much attention to DoD contractor estimating systems? One obvious stimulus was the rash of "horror stories" in the press declaiming outrageous prices for spare parts—$400 hammers, $9600 allen wrenches, $7400 coffee pots. These and other reported examples of pricing problems stirred congressional committees to action. In 1983 and 1984, hearings were held by the following committees:

House Government Operations Committee

House Armed Services Committee

House Small Business Committee

Senate Appropriations Subcommittee on Defense

Senate Armed Services Committee

Senate Governmental Affairs Committee

Senate Small Business Committee

Senate Judiciary Subcommittee on Administrative Practices

Secretary of Defense Weinberger ordered the DoD IG to perform a comprehensive review of spare parts pricing.(8) The review encompassed 95 contractors at 460 locations, some 11,602 pricing actions valued at $87.1 billion. Following are examples of findings in that audit:

Material costs not updated

Lower negotiated purchase order prices not disclosed

Work order (lot) history not updated

Vendor quotes not current

Inaccurate labor standard adjustments used

Accelerated deliveries (earlier lots) not disclosed

Gain on sale of capital assets not disclosed

Labor rates/factors not current

Factory overhead forecast not disclosed

Tool and test equipment cost data not disclosed

Thus the spare parts overpricing problem was seen to be caused, in large part, by deficiencies in contractor estimating systems.

Another factor that focused attention on estimating systems was a continuing high level of defective pricing being uncovered and reported by DCAA. Public Law 87-653, the Truth in Negotiations Act(9), requires contractors (with some exceptions) to certify that their cost or pricing data are accurate, complete, and current. Covered contracts that do not meet this requirement are considered to be defectively priced; the contracting officer can unilaterally reduce the contract price.

According to William H. Reed, DCAA Director, during 1985, 1986 and 1987, DCAA averaged about 850 positive findings per year—that is, the auditors found defective pricing on that many contracts. Of particular significance was that they found defective pricing on half the contracts they reviewed. They recommended contract price adjustments of $933 million per year, on average(10).

Many in the contracting community and in Congress came to the conclusion that the high incidence of defective pricing was attributable to poor estimating systems. William J. Sharkey, DCAA Assistant Director of Policy and Plans, enumerated the following indicators of estimating deficiencies(11):

The lack of clearly documented contractor policies, standard procedures, and methods covering the estimating system area.

Nonexistent, out-of-date, or inadequate support for factors used in the proposal.

Failure to perform an adequate review of proposed subcontracts prior to the submission of the proposal.

The lack of budgetary data beyond the current year.

Policies which require that all possible production effort remain within the company, regardless of the comparative cost of the effort.

Proposing material on a stand-alone basis and not considering other known requirements that might be ordered at the same time.

Proposing vendor quotes that do not consider history which indicates that prices ultimately negotiated with the vendors are lower than quoted.

Not considering or selectively using historical cost experience for similar programs.

Not considering residual inventories.

Applying escalation to firm vendor quotes.

By 1985, it was clear that contractor estimating systems in general needed to be improved.

## CHANGING THE RULE

In early 1986, behind the scenes effort to change the estimating system coverage in the FAR became visible. Both the Air Force and DCAA submitted proposals to the DAR Council. These proposals were incorporated into DAR Case 86-109 and were sent to the DAR Pricing Committee for review. The review was lengthy.

In April 1987, Congressman Jack Brooks, Chairman of the Legislation and National Security Subcommittee, held a hearing on defense contractors' estimating systems(12). In his testimony, Frank Conahan of the GAO presented a number of examples of estimating deficiencies, and stated that the Air Force and DCAA FAR amendments proposed in June 1986 would be a good starting point to arriving at acceptable contractor estimating systems. Dr. Robert Costello, then Assistant Secretary of Defense (Acquisition and Logistics), testified that the DAR Council would act on the contractor estimating case in the next several months.

On July 17, 1987, a proposed rule to the DoD FAR Supplement was published in the Federal Register(13). The summary stated:

"The Defense Acquisition Regulatory (DAR) Council is proposing to revise Section 215.811 to the DoD FAR Supplement (DFARS) to (1) require that certain large business entities establish and maintain adequate estimating systems, depending on the dollar value of contracts received in the preceding fiscal year; (2) provide guidelines for and characteristics of adequate estimating systems; and (3) provide procedures for conducting estimating systems reviews by the government."

Public comments on the proposed rule were to be submitted to the DAR Council by September 15, 1987.

Agency members of the DAR Pricing Committee had not been unanimous in approving the language in the proposed rule. Members representing the Air Force, DCAA, and the Assistant Secretary of Defense (Comptroller) submitted minority reports expressing concern that the proposed coverage failed to protect the government's interest. The major objection was that the proposed rule would allow contracting officers to proceed with negotiations when part of a contractor's system had been disapproved. The minority opinion was that the government should be protected by either making the correction of all deficiencies a condition of contract award, or by including a cost savings clause in contracts that would allow the government to recover overpricing that resulted from significant estimating deficiencies.

After receipt of the public comments, The DAR Council elected to have its staff review the comments and make revisions to the proposed rule. They did this rather than follow the more usual procedure of sending the comments to the Pricing Committee members for them to review and incorporate into a final rule. This may have been done to make for more expeditious issuance of the final rule, considering the differences of opinion among the Pricing Committee members. However, the first real revisions were not made until December 1987 when in a series of meetings the DAR Council decided on the following:

<u>Added</u>

A policy statement that all contractors should have a good estimating system

A statement that the estimating system should be integrated into and not be in conflict with other systems

As an indicator of potentially significant estimating deficiencies, the failure of the system to integrate with other systems

<u>Changed</u>

Applicability levels for disclosing and review from $25 million mandatory, $10 million optional to $50 million mandatory, $10 million optional

The definition of a significant estimating deficiency by removing quantitative criteria

<u>Deleted</u>

The access to records portion of the clause

The requirement to advise the ACO at least 60 days prior to making any changes to its estimating system

The DAR Council issued the final rule on March 18, 1988.

## THE FINAL RULE

As noted above, it is DoD policy that all contractors have adequate estimating systems. In addition, certain large contractors must disclose their estimating systems to the administrative contracting officer and must respond to any reports which identify deficiencies in the systems.

A contractor is subject to the disclosure and response provisions if it is:

a large business and

in its prior fiscal year received DoD prime contracts or subcontracts for which certified cost or pricing data were required totalling $50 million or more; or

in its prior fiscal year received such DoD contracts totalling $10 million or more when the contracting officer determines it is in the best interest of the government.

If a contractor is required to disclose its estimating system to the ACO, the disclosure must be adequate. A disclosure is adequate when the documentation:

accurately describes the policies, procedures and practices used in preparing cost proposals; and

provides sufficient detail for the government to reasonably make an informed judgment regarding the accuracy of the contractor's estimating practices.

In order to meet the maintenance requirement, the contractor must disclose any significant changes to the cost estimating system on a timely basis to the ACO.

The DoD rule does not spell out specific requirements for adequate estimating systems, but instead provides general guidance. It states that adequacy is dependent on the successful interrelationship of many variables. The relative importance of each is determined by the particular circumstances facing each contractor. In general, adequate systems should:

provide for the use of appropriate source data

utilize sound estimating techniques and appropriate judgment

maintain a consistent approach, and

adhere to established policies and procedures.

The rule also lists examples of the types of characteristics which should be considered by the ACO when evaluating a system. Though not intended as a checklist, they will be useful to government and contractor personnel alike. The ACO should consider whether the contractor's estimating system:

establishes clear responsibility for preparation, review and approval of cost estimates;

provides a written description of the organization and duties of personnel preparing, reviewing, and approving estimates, and the various functions that contribute to the process (e.g., accounting, planning, etc.);

assures that personnel have sufficient training, experience and guidance to perform estimating tasks in accordance with established procedures;

identifies the sources of data and the estimating methods and rationale used in developing cost estimates;

provides for appropriate supervision throughout the estimating process;

provides for consistent application of estimating techniques;

provides for detection and timely correction of errors;

protects against cost duplication and omissions;

provides for the use of historical experience where appropriate;

requires use of appropriate analytical methods;

integrates information available from other management systems as appropriate;

requires management review including verification that the company's estimating policies, procedures and practices comply with the regulation;

provides for internal review of and accountability for the adequacy of the estimating system, including the comparison of projected results to actual results and an analysis of any differences;

provides procedures to update cost estimates in a timely manner throughout the negotiation process; and

addresses responsibility for review and analysis of the reasonableness of subcontract prices.

The DoD rule provides further guidance on estimating systems by listing some indicators of conditions that may produce or lead to significant estimating deficiencies:

failure to assure that relevant historical experience is available and used;

continuing failure to analyze material costs or to perform subcontractor cost reviews as required;

consistent absence of analytical support for significant proposed cost amounts;

excessive reliance on personal judgment where historical experience or commonly used standards are available;

recurring significant defective pricing findings within the same cost elements;

failure to integrate relevant parts of other management systems;

failure to provide established policies, procedures and practices to persons responsible for preparing and supporting estimates.

The DoD regulation specifies detailed government review procedures. Reviews are to be on a team basis with the contract auditor designated as team leader. The next section covers the review process in some detail.

Following the review, the auditor will issue to the ACO a report outlining the findings and recommendations of the review team. If there are significant estimating deficiencies, the report will recommend disapproval of all or part of the estimating system. Field pricing reports will also mention any significant deficiencies that remain unresolved.

The ACO will provide a copy of the audit report to the contractor and allow 30 days for submission of its written response. If the contractor agrees with the report findings and recommendations, it should make corrections to identified deficiencies or submit a plan of action for doing so. If the contractor disagrees with the report findings, the response should give the rationale for the disagreement.

The ACO, in consultation with the auditor, will evaluate the contractor's response and determine whether

the estimating system contains deficiencies which need correction;

any of the deficiencies are so significant as to result in disapproval of all or a portion of the system;

any proposed corrective actions are adequate to correct the deficiency.

If there is a determination of such deficiencies, the ACO will notify the contractor that corrections or a corrective action plan are due within 45 days.

The auditor and ACO will monitor the contractor's progress toward correction. If adequate progress is not made, the ACO can consider the following actions:

bringing the issues to the attention of higher level management;

reducing or suspending progress payments;

recommending nonaward of potential contracts.

If within 45 days the contractor has neither submitted an acceptable corrective action plan nor corrected significant deficiencies, the ACO will disapprove all or a portion of the estimating system in writing. A copy of the notice of disapproval will be sent to each contracting office and contract administration office having substantial business with the contractor.

Under the regulation, when a contracting officer determines that an estimating system deficiency has a significant impact on a contract under negotiation, he or she should consider pursuing such alternatives as:

allowing the contractor additional time to correct the deficiency and submit a corrected proposal;

considering another type of contract;

segregating the questionable areas as a cost reimbursable line;

reducing the profit or fee objective;

including a contract clause that provides for adjustment of the contract amount after award.

After the rule was published, DCAA headquarters personnel noted one or two instances where the language might be misinterpreted or misunderstood. They suggested clarification be made. Defense Acquisition Circular No. 88-5 dated March 1, 1989, contained two minor revisions "to clarify and facilitate understanding and appropriate application of the requirements of DFARS 215.811."

## THE REVIEW PROCESS

The rule provides rather general directions on the review process. Audit and contract administration activities are required to establish and maintain regular programs for reviewing selected contractors' estimating systems. Reviews are to be accomplished as a contract audit and contract administration team effort, with the auditor acting as team leader. Teams will include audit, contract administration and technical specialists.

Reviews will be made at least every three years of contractors who meet the criteria for disclosure and maintenance requirements cited above. This period may be extended if the auditor and ACO determine that past experience and a current vulnerability assessment disclose low risk. On the other hand, reviews will be done more frequently if the auditor and ACO determine that the government is at high risk.

The rule is clear about apprising the contractor of audit findings. To the extent possible, the team leader should inform the contractor and the ACO of significant findings during the review, and should hold an exit conference to cover the significant findings at review's end.

The DCAA has developed a comprehensive audit program(14) to be used for either the comprehensive reviews it continues to perform or the DCAA/contract administration office team reviews required under the new rule. Comprehensive reviews relate to effort expended solely by auditors, although DCAA management recommends that the audit office request technical assistance on the qualitative aspects of the proposed direct material, direct labor, and other cost elements.

Under DCAA policy, the requirement for a team review specified in the new rule may be waived or modified by the written approval of the DCAA Regional Audit Manager in coordination with the ACO, if past experience and a current vulnerability assessment indicate low risk. The policy also conforms to the rule requirement for more frequent reviews if the government is found to be subject to high risk.

To assess the risk at each contractor location, DCAA developed an estimating system vulnerability assessment procedure (ESVAP) and included it as a supplement to the audit program. The ESVAP is used to determine which contractors require an estimating system survey, and the specific areas of vulnerability within the individual contractor systems. The DCAA Headquarters guidance requires that auditors complete the ESVAP on all contractors which in their preceding fiscal year received DoD prime contracts or subcontracts totalling $50 million or more, for which certified cost or pricing data was required.

Upon completion of the ESVAP and determination that a team review is indicated, the review team uses the comprehensive audit program as a guide. The program, some 35 pages of detailed steps, may be compressed or lengthened depending on an individual contractor's circumstances and results of the ESVAP. Following are the main areas of coverage:

Preliminary Audit Effort

- Review permanent files
- Assess compliance of system with CAS
- Determine extent of corrective actions taken
- Coordinate with ACO and contractor (including entrance conference)
- Set up team assignments

Review System for Adequacy and Compliance

- Organization and assignment of responsibilities
- Policies and procedures
- Internal controls and managerial reviews
- Cost accounting system
- Budgets and forecasts
- Cost estimate development
- Proposal format and support
- Direct materials and subcontracts
- Direct labor
- Other direct costs
- Indirect costs
- Facilities capital cost of money
- Special tooling/test equipment

Concluding steps include summarizing findings and recommendations, preparing a draft report, holding an exit conference with the contractor, and issuing the final report. The contractor has an opportunity to express its reaction at the exit conference, and the final report will contain this and the auditor's response to the contractor's reaction. Procedures to be followed after the final report is issued are covered in the previous section of this paper.

## SURVEY RESULTS—ESTIMATING PRACTICES

Recent surveys(15) on estimating practices among contractors turned up results that were both interesting and surprising. The polls were conducted at recent Touche Ross seminars.

Attendees were asked whether their estimating procedures were (1) written, (2) reviewed by DCAA, or (3) approved by DCAA. Almost 40% of the attendees have no written procedures. Over 80% either had no written procedures, no DCAA review, or a DCAA review without a DCAA exit conference/response. Only 8% had passed a DCAA review; 12% had flunked.

Techniques for estimating material costs varied significantly. About 35% say that they attempt to use material prices that are no older than six months for at least 80% of the material dollars. About 10% use the most recent material price regardless of age. About 20% of the replies show an attempt to use prices no older than one year for 80% of the material dollars. The same percentage response was recorded for (1) use of price within six months for all material and (2) use of price within one year for all material.

The following methods were used to escalate labor costs:

- Union agreements, 12%
- Historical data, 20%
- Budget, 32%
- DRI forecasts, 28%
- A forecast other than DRI, 24%

Some companies use more than one method.

In estimating indirect costs, most (62%) contractors use budgetary data. About 10% say they use the most recent completed year and less than 10% use rates from the most recently audited year. About half say that the last year of indirect cost rate settlement was before 1985.

Use of mathematically based estimating techniques was surprisingly high. More than 50% use improvement curves. Parametric estimating is used by about 35% of the attendees and another 20% use regression analysis.

Concern over defective pricing allegations is evident in that attendees are taking preventive actions. About 40% of the contractors conduct regular training sessions. Nearly 30% use a data sweep approach between date of price agreement and the signing of the certificate of cost or pricing data. Another 20% require the buyer to sign off on data received during negotiations and still another 20% require internal certifications by company employees.

Government reviews of material management and accounting systems have not been completed in any great numbers. About 25% are not subject to a self-assessment. Over 50% are waiting for the government to review their self-assessment. About 10% have had acceptable demonstrations and 5% have had unacceptable demonstrations.

Exemptions from cost and pricing data have been used to some extent. About 45% claim that adequate competition has been used as an exemption. Another 20% use the catalog price exemption. About 10% use the market price exemption.

## SOFTWARE AND ESTIMATING SYSTEMS

Many contractors are currently using software in some aspect of their estimating process. In light of the new emphasis on estimating systems many contractors will be reviewing their use of estimating software.

The control objective of all electronic data processing (EDP) systems is the processing of accurate data (16). Beyond this objective, contractors may wish to incorporate the DFARS estimating system guidelines into their estimating software.

As previously discussed, the new DFARS 215.811 guidance provides that adequate estimating systems should use appropriate source data, utilize sound estimating techniques and appropriate judgment, maintain a consistent approach, and adhere to established policies and procedures. Good estimating software should help implement these objectives.

Each contractor has its own organizational structure and its own methods of operation. The larger the contractor is, the more diverse are the people involved in the estimating process. The implementation of any organization structure is only as good as the corporate personnel. Most contractor personnel are highly ethical, yet even the best of people are subjected to the pressures of competition.

A good management information systems (MIS) should decrease the decisions needed by the end user, and implement management policy at the same time. A good estimating software system should include, as a minimum: mechanisms to insure that appropriate pricing data is used, that corporate methodologies are applied consistently, that the estimating process is auditable (17), and that current cost or pricing can be certified. There may be many other complexities to be considered, based on the size and sophistication of each contractor.

## CONCLUSIONS AND SUMMARY

The new DoD rule on estimating systems will have a significant impact on the government contracting community. Contractors will expend more effort in developing , disclosing, and improving their systems, while auditors and contracting officers will devote more of their time to reviewing and monitoring systems and following up on recommendations. Not yet determined is the extent of improvement this added effort and attention will bring to contract pricing. Interested people in DoD and Congress will be keeping close tabs on results, especially spare parts and defective pricing. Surveys indicate that contractor implementation has only just begun. The DCAA and contract administration offices have geared up for a major effort, with estimating system vulnerability assessment and detailed audit programs, and have started making team reviews. Contractors who have not yet been reviewed can be relatively sure they will be, especially the majors; it's only a matter of time and availability of audit resources. They can also be sure that auditors and contracting officers will closely monitor any needed corrective actions, in this era of increased attention to estimating systems.

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## EXCHANGE RATES AND PRODUCT COST

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### FOREWORD

This paper is the condensed version of a research report under preparation by the author, working as professor at the Research Department at the Defense Systems Management College. Mathematical formulations and supporting material, like spread sheet calculations have been left out for the condensed form; partially in order to avoid information overload, partially because the material has not reached publishable form.

The ultimate goal of the research is to provide future project managers and acquisition executives with a computerized working tool, enabling them to arrive at an educated judgment about the meaning of exchange rates to the cost of a specific project with foreign components or developed in co-production with NATO partners.

The immediate purpose for publishing this paper is first to introduce a new point of view toward the subject of exchange rates and second to solicitate comments from the acquisition community. The scope of the present version is tailored to the perceived needs of the acquisition community. This, however, does not preclude the possible interest in the subject by students of political economy.

### PART I
### EXCHANGE RATES AND PRODUCTS

The purpose of this part is to provide a general understanding about the meaning of variations in the exchange rate between the U.S. dollar and other currencies with regard to the cost of specific products. This understanding is important for all managers and decision-makers of major acquisition programs in DOD and other institutions.

A series of knowledge elements are explained and simple sample calculations are used. Each building block necessary for the understanding is of fundamental simplicity; what makes the subject slightly difficult, is the interaction of the building blocks. Nevertheless, I tried to provide easily understandable explanation. If they read too tutorial, I apologize. But what can you expect from a teacher by choice?

### CURRENCY AREAS

All economic activities in the western world with full convertible and relatively inflation free currencies take place in two currency areas: First in the U. S. dollar area and second in the NON-dollar area.

The Dollar-area includes, of course, the U.S.A. itself but also, the four countries of Korea, Taiwan, Hong Kong and Singapore (HBR #6, 1989, p.79). The currencies of these four listed places are linked to the U.S. dollar and they move against all other world currencies together, with the U.S. dollar up or down. Hence, the import and export posture of all countries of the dollar-area is identical affected by a U.S. dollar evaluation or devaluation; however, their relative trade pattern among themselves is not influenced. For example, a devaluation of the U.S. dollar will neither deter imports from Formosa into the U.S.A., nor support exports from the U.S.A. to Formosa. The group of five are among themselves "exchange-rate-neutral" with regard to economic advantages or disadvantages. But (for the purpose of the present paper) not only "countries" but also specific "commodities" belong to the dollar area, like oil or ore which are traded and quoted on the world market in U.S. dollars.

The NON-dollar area shall include (for the purpose of the present paper) Japan, all countries of Europe-1992 and the four non-aligned European traders of Switzerland, Sweden, Austria and Finland. The currencies of these NON-dollar areas are free floating against the U.S. dollar and their ratio will change on a daily basis against the U.S. dollar. The relationships among the NON-dollar currencies is also variable but nevertheless surprisingly stable although no lead-currency in itself is formerly established. Hence internally, this Japanese-European NON-dollar area is also neutral to changes in the exchange rate of the U.S. dollar.

AREA INTERACTION

The Dollar-area and the NON-dollar-area interact either by necessity or by convenience with each other. The link between the two areas is established by "products" and "markets."

In the trivial case, each area is the originator of 100% area products; this means all raw materials and all value-added operations are exclusively originated in one of the two areas and, thereafter sold to its own market and/or to the market of the other area. Hence, we have two product origins and two markets. For this case, we assume tacitely that each area is self sustained and the exchange of products is a matter of convenience or competitive advantages of the long bygone world of Adam Smith (1776).

In this trivial model, any change in the exchange rate between the two areas will change the competitive position between these two areas. For example, at 50% devaluation of the U.S. dollar against the German mark will result in a doubling of all cost for imports into the U.S.A. of German originated goods and in a halving of the U.S. export cost. In short, the dollar devaluation subsidizes uniformly all U.S. exports and taxes also uniformly all German imports into the U.S.A., (regardless if such subsidies and/or taxes are of specific product advantage or not).

Above argument is simple, clear, logical and definitely valid in yesterdays world, but, unfortunately, utterly wrong in todays world. It is wrong, because today exists, neither in the dollar-area nor in the NON-dollar area one single product, that does not NEED a contribution from the other area for its making. For example, no "Japanese" car could be produced without imports of raw materials and energy from the dollar-area and no "American" car could be produced without import of components from Japan and other NON-dollar areas.

Of course, in above car example, the situation from the Japanese point of view and from the U.S.A. point of view is not quite identical. There are two fundamental differences: First, Japan MUST import the raw materials and energy it does not have, while the U.S.A import components out of CONVENIENCE for a variety of reasons. Second, as consequence of a dollar-devaluation the Japanese import cost from the dollar-area go down (if measured in Yen) and the U.S. import cost from the NON-dollar area go up (if measured in U.S. dollars).

The reality of area interaction for a specific product like a car can be immensely complicated. The interaction between the dollar-area and the NON-Dollar area can be different for its mechanical parts, its electrical/electronic parts and its chemical components like paint. Parts in its total value added process can cross more than once the boundaries between the dollar and NON-dollar area, triangular and multiple pole relationships might be involved. However, from a conceptual point of view (as adopted for the present paper), the fundamental area relationships and/or interactions can be bonded with a set of six scenarios as sketched in Figure 1.

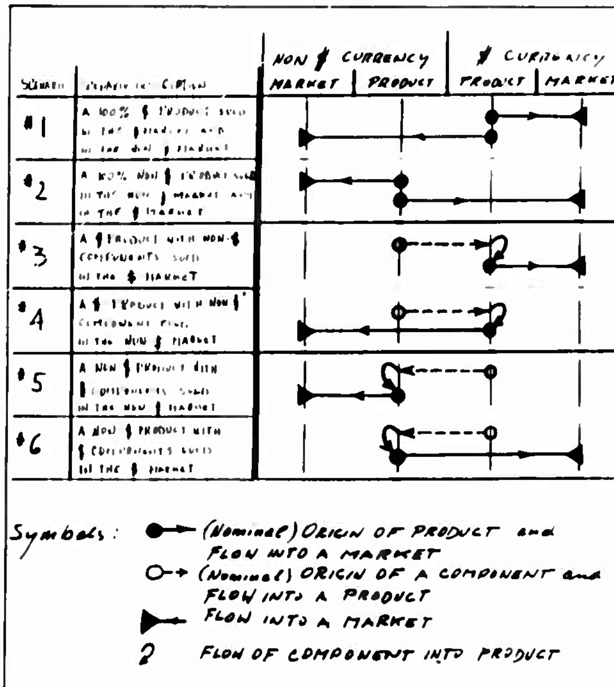


Figure 1. SCENARIOS OF AREA INTERACTIONS

According to this figure, products (full circle) and components (empty circle) can originate in the dollar and the NON-dollar area. It may be, for instance, an American or a Japanese car and component manufacturer. The definition is slightly fuzzy and for this reason we speak about the "nominal" origin; it may be the car manufacturer, who puts his name plate on the car, or in DOD acquisition, the prime contractor. However, the definition serves conceptual purposes. Each (nominal) product in turn can be sold in the market of its own area or in the market of the other area.

The first two scenarios are the primitive cases, representing the trivial model. The last four scenarios represent todays reality.

EXCHANGE RATES

The exchange rate expresses the current value ratio between two currencies. For example, the American traveler to Germany asks "How many German marks will I get for one dollar?" or, in reverse, the German traveler to the U.S.A. wants to know how many dollars he can get for a certain amount of German marks. The American or German exporter and importer will extend this question of how much he can get or has to pay into a longer time frame; i.e., how much in a year from now?

The extended question has been meaningless for more than 25 years, because the Bretton-Woods agreement of 1945 fixed all currencies within the American hegenomy to the U.S. dollar and in turn the dollar was frozen to gold. In economic terms, the dollar was pegged to gold and the dollar the numerair for most world currencies. The Bretton-Woods agreement was the brain child of Lord Keynes. His more daring proposition to establish a uniform world currency failed. The Bretton-Woods agreement provided practically absolute stability of the free world exchange rates.

In 1971, the currency stability started to crumble. First the dollar/gold ratio was changed, the Bretton-Woods agreement was cancelled and by 1973 the dollar and all other currencies started "to float" in its relative value on a day-by-day basis; the economic theories of Milton Friedman were transformed into reality, where the market shall determine the exchange rates.

Today, a partial counter movement against floating exchange rates and toward fixed exchange rates is in the making. I call it "partial," because it concerns Europe 1992 and encompasses serious efforts by the European parliament in Strasbourg to develop a uniform European currency, a uniform European tax system and a European central bank. This, however, is future music and all that can be said today with certainty are two things: First, the fascinating history of currencies from 1945 to 2000 will provide ample food for smart dissertations and even smarter afterthoughts; second, with the shift of exchange rates into a variable input, money lost its function as a measurement scale for many economic activities (at least) on the microlevel. In turn, the manager of a product, of goods and services, and of major acquisition projects has to live with this fact.

The meaning of variable exchange rates is demonstrated in Table I.

The entries into Table I are subdivided into six columns and nine lines. The base line, to "start" the calculation, is line number five and the German mark is used as example. In line five we are at the time $t_0$. I suggest to call the time $t_0$ the NOW-TIME and define it as this specific time, from where we measure the impact of devaluation or evaluation of the U.S. dollar (or any other currency). For line five, column #1, you get DM-4 for one U.S.

Table I DEMONSTRATION CALCULATION

| Line # | Col #1 Range of EXCHANGE RATES i.e. German Marks (DM) you may get for one US $ | Col #2 VALUE of the US $ at different exchange rates in Percent | Col #3 CHANGE in exchange rate in percent of devaluation or evaluation | Col #4 Amount of $ you have to pay for DM 4 of goods in IMPORT | Col #5 Amount of DM you get for $1 of goods in EXPORT | Col #6 TIME |
|---|---|---|---|---|---|---|
| 1 | 0.0 | 0 % | - 100 % | ∞ 1/ | 0 1/ | |
| 2 | 1.0 | 25 % | - 75 % | 4.00 | 1.0 | |
| 3 | 2.0 | 50 % | - 50 % | 2.00 | 2.0 | $t_1$ |
| 4 | 3.0 | 75 % | - 25 % | 1.33 | 3.0 | |
| 5 | START 4.0 | 100 % | START ±0 | 1.00 | 4.00 | $t_0$ |
| 6 | 5.0 | 125 % | + 25 % | 0.80 | 5.0 | |
| 7 | 6.0 | 150 % | + 50 % | 0.67 | 6.0 | |
| 8 | 7.0 | 175 % | + 75 % | 0.57 | 7.0 | $t_1$ |
| 9 | 8.0 | 200 % | + 100 % | 0.50 | 8.0 | |

END — The $ goes down — The $ goes up — No end

Devaluation — Evaluation

1/ Limit Paradox (see text)

dollar. In column #2, we define this as the 100% exchange value at time $t_0$ with no change as shown in column #3. In column #4 and #5 we indicate "how much" we have to pay in U.S. dollars for DM-4 as import-item (answer $1) and the DM we get for one U.S. dollar of export (answer DM-4.)

The <u>Key Assumptions</u> for the further calculation of the numbers in Table I, column 4 and 5, line 1 through 4 and 6 through 9 are:

- First, we assume that the internal or domestic cost (not prices) of $1 (for the U.S. product, and of DM-4 (for the German product) remains constant from the time $t_0$ through all other times $t_i$.
- Second, the only variable for imports into the U.S.A. and exports to Germany are the exchange rates.

We need those two assumptions in order to establish an analytical baseline. Variations will follow. Besides, these two assumptions are not as unrealistic as you might think they are. Just try to get a quote in U.S. dollars from a European hotel for your summer vacation next year. You will not get it. All quotations will be in the "stable" local currency and you will have to pay in dollars according to the prevailing exchange rate at the date of your hotel bill.

In column #3 the percent changes of the exchange rate (against the value of 0 at the time $t_0$) are shown. The most significant figures in column #3, #4 and #5 are in line 1. It shows that the U.S. dollar can not be more than 100% devaluated, which means, the dollar becomes utterly worthless. At this moment (column #4), we in the U.S. would have to pay an infinite amount of dollars, to import DM-4 from Germany and the Germans (column #5) could buy one dollar of U.S. merchandise with zero DM; this means, they could get everything for free. In reverse, if the dollar would be evaluated by 100% (line 9), we in the U.S. could get all German products for the half amount of dollars and the Germans would have to pay in DM twice for imports from the U.S.A. In the extreme, if the dollar could be evaluated to an infinite value, the U.S. could import everything for free from Germany. Of course, such extremes are not quite realistic, at least we hope so, and shall be called the "limit paradox."

The limit paradox, however, shows beyond the shadow of a doubt, that the study of evaluation and devaluation among two currencies and two economic partners has two sides and, without identifying the two sides, the story reads as follows:

- MY devaluation is YOUR evaluation
- MY evaluation is YOUR devaluation
- MY devaluation is YOUR import tax and MY export subsidy
- And so forth accordingly to your fantasy.

The MY-YOUR story is summarized in Figure 2: the devaluation and evaluation of the lead currency, assumed to be the U.S. dollar, is expressed in percent, starting with zero at the time $t_o$. The impact of this evaluation or devaluation is measured in percent against the cost (not price) of 100% at time $t_o$ and two relationships are shown. First a straight line, showing the import cost of a distinct (or 100%) U.S. product into a foreign NON-dollar country to be paid in the foreign currency, and second a sloped curve, showing the import cost of a distinct (or 100%) foreign product, originated in the NON-dollar area and imported into the U.S.A. and be paid in U.S. dollars.

Figure 2 shows in crudest form the two sides of the coin for the simplest of all possible condition: assuming that a "100% U.S. product" and a "100% foreign product (i.e., German)" exist. Refinement follows.

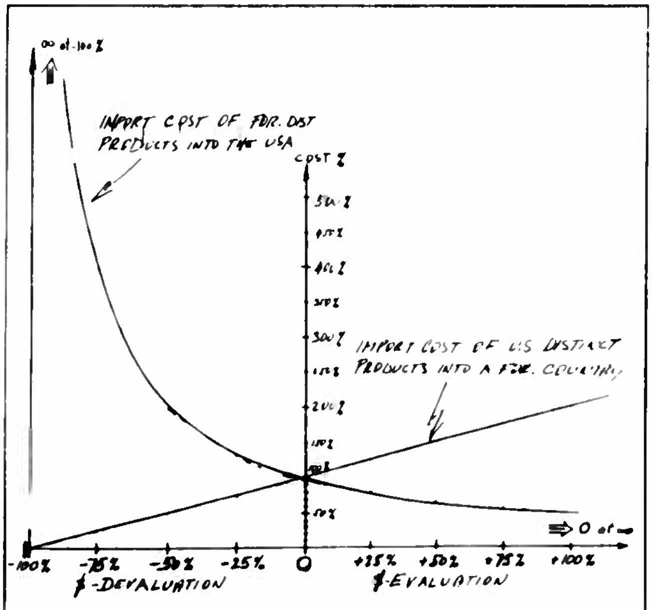


Figure 2 IMPORT COST VS. EXCHANGE RATES

## EXCHANGE RATES AND FOREIGN CONTENT

We define "foreign content as that part of a domestic product imported in the form of material or components as needed in making the product. Japan, for example, may have to import raw material in order to make a Japanese car and the U.S.A. car manufacturer may have to import electronic components to make his American car.

We can measure the amount of foreign content either in physical terms or in monetary terms. In physical terms we may, for example, state that a U.S. steelmill making a special steel needs for each 100 tons of steel one ton of chrome from Zimbabwe (formally Rhodesia) or from Russia and a half-ton of nickel either from Canada or Indonesia. Hence, the foreign content is one and a half ton in 100 tons of a American produced special steel. Economists of course are measuring in monetary terms and they will tell us that 30 percent of the value added to a product is imported foreign content, and 70 percent is truly American added value, to be measured in U.S. dollars. De facto, the monetary measurement is very practical and truly meaningful, as long as the dollar is (or, better, was) stable in its relationship to other currencies. However, as soon as the exchange rate shifts from a "constant" into a "variable," the entire measurement system collapses and all relations, for instance between foreign and domestic content move with the changes in the exchange rate disregarding the fact that physical relations and physical properties of the product and its process remain constant. (Other variables like inflation are presently not considered).

In order to explain the relationship between exchange rates and foreign content in its most rudimentary form, we assume to have an "American product" ($P_o$) at the time $t_o$ with a cost of $100 as shown in Figure 3. Here we assume the APPARENT PRESENT RATION ($R_1$) to be 70 to 30. This means, it appears as if a product may have 70% domestic U.S. content and 30% foreign content if measured in dollars at the time $t_o$.

Assume, the foreign content (30%) of the "American" product comes from a NON-dollar area; i.e., Japan. Now we have to look at the foreign content from the Japanese point of

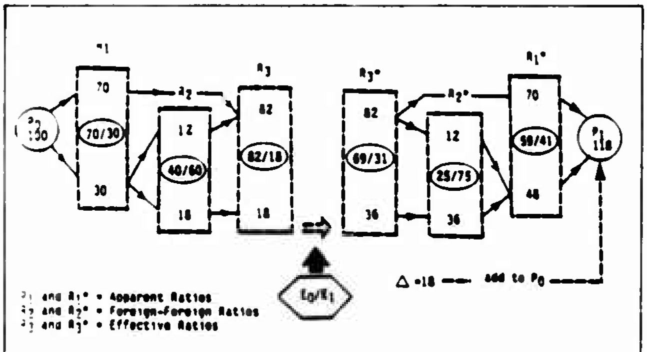


Figure 3 EXCHANGE RATE AND FOREIGN CONTENT

view at the $t_o$. We may find out that the Japanese 30% or $30 content of the American product is really not a true Japanese product. Japan needs at the time $t_o$ an import from the dollar area for raw material and energy in the amount of $12 and only $18 is at the time $t_o$ the value-added contribution in Japan. Hence, Japan's foreign content is $12 or 40% of the Japanese product. We call this the FOREIGN-FOREIGN RATIO ($R_2$).

Now, we can take a new look at our "American" product at the time $t_o$: The apparent ration ($R_1$) informed us, that the product has 70% or $70 American content; the foreign-foreign ratio ($R_2$) informed us, that 40% of the Japanese content, or $12 is originated in the dollar area. Hence, the American product has de facto a $82 or 82% content originated in the dollar area and only $18 or 18% content from the NON-dollar area. The ratio 82/18 is the EFFECTIVE RATIO ($R_3$) of dollar/NON-dollar content of the American product.

The shift from the apparent ratio ($R_1$) to the effective ratio ($R_3$) through the analysis of the foreign-foreign ratio ($R_2$) has practical value for the calculation and is based upon the assumption that all value-added parts of a product originated within the dollar area will not be affected by a change in the exchange rate; only the value added parts originated in the NON-dollar area will be affected. Hence, the apparent ratio ($R_1$) represents the sovereignty point of view, while the effective ratio ($R_3$) represents the currency area point of view. Between those two points of view is the world of financial and power politics, far beyond the scope of the present paper.

Now the exchange rate enters the picture. Assume at the time $t_i$ the exchange rate between dollars and yen ($E_o/E_1$) changes and the dollar loses 50% in exchange power. This changes at time $t_i$ first the effective ratio ($R_3$) from 82/18 to 69/31 ($R_3^*$). Consequently, the foreign-foreign ratio will change from 40/60 ($R_2$) to 25/75 ($R_2^*$). Also the apparent ratio will change from 70/30 ($R_1$) to 59/41 ($R_1^*$) and the price of "100" ($P_o$) will increase to "118" ($P_1^*$). Differently expressed, only the $\Delta$=18 will be added to $P_o$.

Above example, in all its simplicity, illustrates nevertheless two problems: first, the problem of measurement introduced by floating exchange rates and, second, the problem of knowledge or, better, acquisition of this knowledge which we need to deal with floating exchange rates on a specific product basis. Both problems are interconnected:

- o First, we must know the apparent ratio $R_1$.
- o Second, we must know the exchange rate at the time ($t_o$) when $R_1$ has been determined.
- o Third, we must know the foreign-foreign content of the foreign components $R_2$ and
- o Fourth, the exchange rate for the foreign-foreign parts.

If and only if we know $R_1$ and $R_2$ at the time $t_o$ are we in a position to conduct a quantitative calculation or meaningful estimate about the possible impact of changes in the exchange rate. The value of $R_3$, the effective ratio, will be the result of this calculation.

If we do not know these ratios, we can calculate nothing. $R_1$, $R_2$ and $R_3$ must be known as fundamentals before any refinement can be introduced into the calculation, such as market forecasts for raw materials or speculation about changes in the profit rate for our foreign suppliers.

Various Interpretations of the impact of the changing exchange rate can be deducted just from a visual inspection of Figure 3. First we notice a non-linearity between the 50% change in the exchange rate and the price of the American product with its foreign components: The price goes up by 18% from $P_o$ to $P_1$, obviously as a function of the quantity of the physical foreign content. Second, the domestic/foreign content ratio of 70/30 of the American product ($R_1$) changes into a 59/41 ratio ($R_1^*$), which means the domestic content goes down and the foreign content of the American product goes up. Third, we notice that from the Japanese point of view the Japanese product gets even more Japanese; originally ($R_2$) the Japanese product was 60% Japanese, now (at $R_2^*$) it is 75% Japanese. Fourth, the apparent ratio ($R_3$) of 82% content from the dollar area and 18% from the non-dollar area has changed into a 69/31 ratio ($R_3^*$). All ratios (and their related economic indicators) have changed, although it is the same physical product at time $t_o$ and time $t_i$.

## SAMPLE CALCULATION

The purpose of the sample calculation is to demonstrate, in the simplest possible form, what the change of exchange rates means to an American product with a foreign content from Germany. What does it mean, if the American product is sold in the American market and what does it mean if it is exported to Germany?

The sample calculation is carried out for two different time frames: First for the time $t_o$, when one U.S. dollar bought four German marks and for a later time $t_i$, when one U.S. dollar bought only two German marks. In order to simplify the calculation, we made two assumptions: First, the physical product and all processes for its making will not change between the time $t_o$ and the time $t_i$; second, the costs of American value-added portion does not change if measured in U.S. dollar, nor does the German value-added portion change if measured in German marks. These simplifying assumptions are justified because exchange rates change on a daily basis while products, processes or material added-value cost change rather slowly.

The calculation is made for three different scenarios.

Scenario #1:

- We are at the time $t_o$ and \$1 buys DM 4.
- We have a (so called) American product from an American manufacturer and the cost of this product is \$100.
- If we look closer at this American \$100 product, we find that only 70% of it (or \$70) are truly domestic U.S.A content and 30% (or \$30) of the product is foreign content, imported from Germany.

Hence, the COST COMPOSITION looks like this, if seen from the American and the German point of view:

| | | | | | |
|---|---|---|---|---|---|
| U.S. content | 70% | = | \$70 | = | DM 280 |
| German content | 30% | = | \$30 | = | DM 120 |
| Total | 100% | = | \$100 | = | DM 400 |

This means, with a fixed exchange rate of 1:4, the American product cost \$100 or DM 400, regardless if it is sold in the American market or after export in the German market. This of course describes the bygone world of Bretton-Woods where the exchange rate was stable for more than 25 years.

Scenario #2:

- We are at the time $t_i$ and \$1 buys DM 2 because the U.S. dollar has been devaluated by 50% versus the previous time $t_o$.
- We assume, that the German content is to be 100% originated in Germany. This means, from the German point of view, the German part has no foreign content. (This assumption was irrelevant in Scenario #1).

  The COST COMPOSITION of our American product must now be considered from two points of view: from the U.S.A. one and the German one.

  The American cost composition looks like this:

| | |
|---|---|
| U.S. content unchanged | \$70 |
| Germany content, de facto DM 120 or in dollar | \$60 |
| Total | \$130 |

We also note, that the 70/30 ratio at time $t_o$ for the U.S. domestic/foreign content has changed into 54/46 ratio, with 54% American and 46% foreign content at the time $t_i$.

The German cost composition looks like this:

| | | | |
|---|---|---|---|
| U.S. content unchanged | (\$70) | = | DM 140 |
| German content with unchanged DM 120 | (\$60) | = | DM 120 |
| Total | (\$130) | = | DM 260 |

This means, after a dollar devaluation from a 1 to 4 ratio down to a 1 to 2 ratio, the American cost has increased from \$100 to \$130 but, if exported to Germany, the German cost have decreased from DM 400 to DM 260 (in comparison to scenario #1). Differently expressed, the American cost increased by 30%, while the German cost decreased by 35%. In the language of professional economists, one might say that the 50% dollar devaluation resulted in a 30% inflation at the U.S. market and a 35% export subsidy for the product under consideration. Please note that figures for inflation (30%) and the subsidy (35%) are not symmetrical.

We also note that our product (if imported into Germany) has now, from the German point of view, 46% German content and 54% American content versus 30% German and 70% American at the previous time $t_o$.

Scenario #3:

- We are (like in scenario #2) at the time $t_i$ and \$1 buys DM2 because the U.S. dollar has been devaluated by 50% versus the previous time $t_o$.
- We assume, that only 60% (at time $t_o$) of the German parts (or components) are truly of German origin, while 40% of it (as seen from the German point of view) at $t_o$ are foreign content; this German-foreign or foreign-foreign content shall consist of raw material bought at the international commodity market (for oil, ore) and, hence, to be paid in U.S. dollars.

  The analysis of the COST COMPOSITION must start now in Germany:

| | | | |
|---|---|---|---|
| The truly German part is now 60% of Dm 120 | DM 72 | = | \$36 |
| The foreign German part is now as before 40% of \$30 or | DM 24 | = | \$12 |
| Total | DM 96 | | \$48 |

  This means that at the time $t_i$, the German cost has dropped (from time $t_o$) from DM 120 down to DM 96 or by 20%, while the import cost into the U.S.A has increased from \$30 to \$48 or by 60%.

The next step in the analysis of the COST COMPOSITION is to combine the German part with its foreign-foreign components with the American part of the American product:

| | |
|---|---|
| The truly American part of the American product remains with | \$70 |
| The German components amount at the time $t_i$ to | \$48 |
| Total in the U.S. market | \$118 |
| and re-exported to Germany | DM 236 |

This means the 50% dollar devaluation increased the cost in the U.S. market by 18% (from \$100 to \$118) and decreased the cost for the product, if re-exported to Germany, by 41%. This result is as function of the foreign-foreign content, somewhere between the results of scenarios #1 and #2.

Table II SUMMARY OF SAMPLE CALCULATION

| | SCENARIO #1 | SCENARIO #2 | SCENARIO #3 |
|---|---|---|---|
| **ASSUMPTIONS:** | | | |
| (1) TIME FOR CALCULATION | $t_0$ | $t_1$ | $t_1$ |
| (2) EXCHANGE RATE $/DM | 1:4 | 1:2 | 1:2 |
| (3) US/GERMAN CONTENT AT $t_0$ | 70/30 | – | – |
| (4) GERMAN/FOREIGN CONTENT AT $t_0$ | – | 100/0 | 60/40 |
| **COST FOR THE U.S.A MARKET:** | | | |
| (5) COST OF U.S-PART IN $ | 70.- | 70.- | 70 - |
| (6) COST OF GERMAN-PART IN $ | 30 - | 60 - | 48.- |
| (7) TOTAL U.S-COST IN $ | 100.- | 130.- | 118.- |
| **COST FOR THE GERMAN MARKET:** | | | |
| (8) COST OF U.S.-PART IN DM | 280 - | 140 - | 140 - |
| (9) COST OF GERMAN-PART IN DM | 120 - | 120 - | 96.- |
| (10) TOTAL GERMAN COST IN DM | 400 - | 260 - | 236 - |
| **COST COMPARISON:** | | | |
| (11) PERCENT COST IN USA | 100% | 130% | 118% |
| (12) PERCENT COST IN GERMANY | 100% | 65% | 59% |
| (13) PERCENT COST INCREASE IN USA | ± 0% | +30% | +18% |
| (14) PERCENT COST DECREASE IN GERMANY | ± 0% | -35% | -41% |
| **CONTENT RATIOS:** | | | |
| (15) US/FOREIGN RATIO IN PERCENT 1/ | 70/30 | 54/46 | 59/41 |
| (16) GERMAN/FOREIGN RATIO IN PERCENT 2/ | – | 100/0 | 75/25 |

NOTE: 1/ OF TOTAL PRODUCT; 2/ OF GERMAN PART ONLY

The cost calculations for the three scenarios are summarized in the Table II.

PART II

## TREND ANALYSIS

The purpose of the trend analysis is to show, in graphical form, how the domestic and foreign content ratios, the cost in the American market and in the foreign markets MUST change as a necessary consequence of variations in the exchange rates. The result of the trend analysis provides a basis to shift from the necessary cost behavior to a possible price behavior.

Throughout the analysis, the U.S. dollar is selected as the lead currency and, therefore, all changes in the devaluation or evaluation refer to the U.S. dollar. All changes and their consequences are expressed in percentages with the time $t_0$ as the departure point for all changes. All cost at the time $t_0$ are defined as 100% cost. Domestic cost for the domestic value-added portion of a product, be it in the U.S.A. or in a European country are assumed to be constant if expressed in the national currency. Hence, cost variation due to national inflation, change in national labor rates or changes in production methods are ignored; only the impact of exchange rates is analyzed.

The analytical steps are outlined in the flowchart of Figure 4.

Each of the analytical steps will be discussed. The sum of the trend analysis will be a basis to develop rational expectation about cost and price for a specific product.

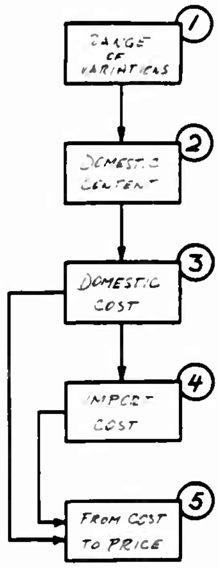


Figure 4 ANALYTICAL STEPS

## RANGE OF VARIATION

Viewed from the American point of view, any product on the American market can be a combination of "domestic content" and "foreign content." For the extreme, the product can be 100% domestic or 100% foreign.

In order to show the two extremes and some in between combinations, a total of five cases have been selected showing different content combinations. The cases are summarized in Table III.

The five combinations are sufficient for the conceptual analysis and permit reasonable interpolation for other content combination. If the resulting graphs shall be produced in a larger size, closer case selection, maybe in steps of 10%, is recommended.

Table III COMBINATIONS

| | CONTENT COMBINATION AT TIME $t_0$ | | |
|---|---|---|---|
| | FOREIGN CONT 1/ | DOMESTIC CONT 2/ | NOTE |
| CASE I | 100% | 0% | The 100% foreign prod |
| 〃 II | 75% | 25% | In between cases |
| 〃 III | 50% | 50% | |
| 〃 IV | 25% | 75% | |
| 〃 V | 0% | 100% | The 100% American prod |

Notes: 1/ ORIGINATED IN THE NON-DOLLAR AREA; i.e. JAPAN OR EUROPE
2/ ORIGINATED IN THE DOLLAR AREA; i.e USA OR FORMOSA

Each of the five cases has been calculated for devaluation of -25%, -50%,-75% and -100% and for an evaluation of +25%, +50%, +75%, and +100%. Devaluation is limited to -100%, which means the currency (in our case the U.S. dollar) lost its value completely. Evaluation, however, can go to any positive amount. At the time $t_o$ of course, neither devaluation nor evaluation takes place; it is the beginning for the analysis.

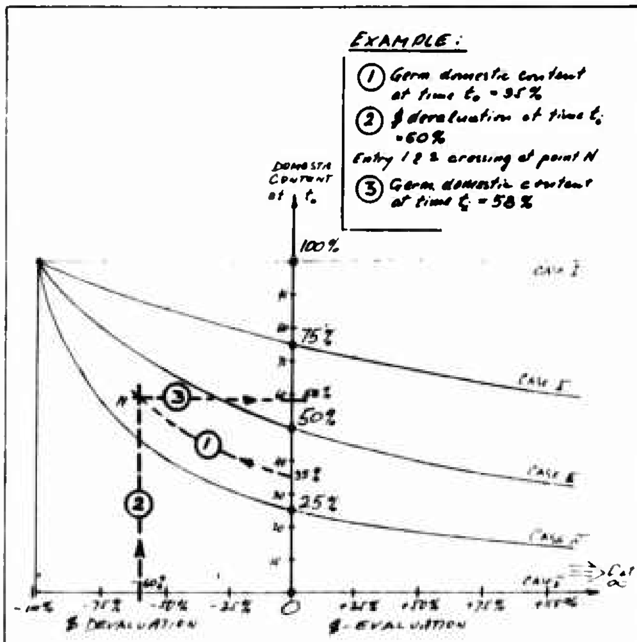


Figure 5 DOMESTIC CONTENT

## DOMESTIC CONTENT

Let's take two products: An American and European product. In physical terms both products share a stable domestic and stable foreign content. In monetary terms, however, the percent composition of domestic and foreign elements changes permanently with changing exchange rates.

Assume you have a German product and this German product may have 0%, 25%, 50%, 75% or 100% foreign content (as seen from the German market). The product with 0% foreign content will always remain a 100% German product, regardless what the $/DM exchange rate will be and, hence, his cost in Germany will be constant. Now consider a case very close to the other extreme: The German product shall consist at the time $t_o$ of 10% of German (or domestic) content and to 90% of foreign content (as seen from the German side) and this 90% foreign content originated in the dollar area; i.e. the U.S.A. Now let's assume at the time $t_i$, the U.S. dollar will be devaluated by 99% to 1% percent of its value as previously existed at the time $t_o$; suddenly the Germans can buy their foreign content for less than 1% of their previous cost and, lo and behold, the former 10% domestic/90% foreign product shifted roughly into a 90% domestic/10% foreign product. As extreme and hopefully exaggerated this example may be, it portrays the problem at hand. The problem is conceptualized in Figure 5.

There is good reason to start the trend analysis with the domestic content of a foreign product: No foreign (European or Japanese) product exists without any significant physical input from the dollar area, although the foreign product may later on be imported into the U.S.A.

## DOMESTIC COST

We are dealing now with a product, originated in a country of the NON-dollar area; i.e. Japan. This product, manufactured in Japan has some foreign content (by Japanese definition). This foreign content shall be bought in U.S. dollars somewhere in the dollar area or the world commodity market, where prices are quoted in U.S. dollars. This foreign content is very expensive, if the U.S. dollar is high; the Japanese have to pay a lot of yens for it. However, the same physical amount of foreign content may be very inexpensive (if paid in yen), when the dollar is very low. Hence, the domestic Japanese cost for their Japanese product with dollar components will go up and down with any and every change in the exchange rate between dollar and yens.

How will the domestic cost in Japan react to changes in the exchange rate? The answer to this question is given in Figure 6, called the domestic cost.

The most important observation by looking at Figure 6 is the fact of a LINEAR RELATIONSHIP between DOMESTIC COST and EXCHANGE RATE VARIATIONS.

If the domestic content is 100% (Case I), then the cost in Japan will not at all be influenced by a change in the exchange rate. However, if the dollar is devaluated to zero (Case V), the dollar part will be of no cost at all to the Japanese. Cases II, III, and IV are intermediate situations with 75%, 50% and 25% domestic (Japanese) content.

The argument can be made, that the dollar <u>prices</u> (not cost) will go up in the international commodity market, if the dollar goes down. This is correct and we have experienced it with the rise of the oil prices by OPEC during the first dollar devaluation in the 1970's. If this is the case, the domestic/foreign content ratio in Japan will change, but the competitive advantages (or disadvantages) of Japan versus U.S.A. will not change in principle with variations in the exchange rate. For clarification of this statement look at the devaluation example in Figure 6. Here, the dollar devaluation by 60%

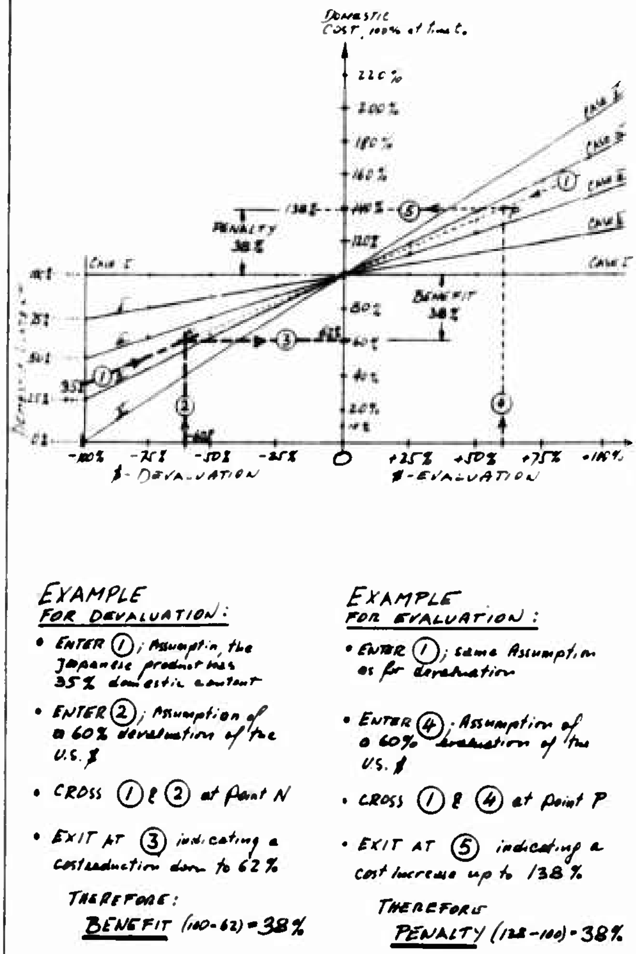


Figure 6 DOMESTIC COST

resulted in a domestic benefit (for Japan) of 38% for a product with 35% domestic (Japanese) value added portion. This 38% benefit can be thrown in to the Japanese cost calculation in order to compensate for a possible price increase of the dollar content (i.e. oil from OPEC) of his specific product; this means the dollar <u>prices</u> for the commodities can increase by a factor of 2.41 before the domestic <u>cost</u> in Japan must go above the 100% mark as established at the time $t_0$, before the devaluation of the U.S. dollar as shown in the example. However, as long as the commodity prices in U.S. dollars are stable, the 38% benefit may apply to the Japanese domestic cost. Furthermore, we notice from the devaluation example, and the evaluation example, that cost benefits and cost penalties are symmetrical.

In retrospect, above conceptual explanation and example might explain, why Japan and Europe was less impacted by the OPEC price increases than the United States: It occurred simultaneously with a dollar devaluation.

<u>IMPORT COST</u>

We are entering now the U.S. market. We have an American product, manufactured in an American factory. But this American product is not 100% American. A certain percentage of it is foreign content, imported from the NON-dollar area; i.e., Japan or Germany. In the extreme, this foreign content can be zero (Case V in Figure 7) or it can be 100% (Case I in Figure 7). In between we have Cases II, III and IV with 75%, 50% and 25% foreign content.

We do <u>not</u> concern ourself with the foreign-foreign content of the imported components for our American product. All we are only asking about are the cost changes of American products in the American (or domestic) market, either because of a dollar devaluation or evaluation for products with different foreign content originated in countries of the NON-dollar area. We call this the IMPORT COST or the "import driven cost" for American products. The conceptual answer to this question is shown in Figure 7, called "The Import Driven Cost."

The term IMPORT DRIVEN COST implies the dependency of many "American" products upon materials and components from foreign sources and/or imports from NON-dollar areas.

Just a visual inspection of Figure 7 shows a NON-LINEAR COST BEHAVIOR and also NON-SYMMETRY FOR DEVALUATION AND EVALUATION. In the condition of a <u>Dollar Devaluation</u>, all import costs go asymptotic to infinite with a complete (or 100%) devaluation of the U.S. dollar, regardless of how small (or large) the foreign content may be. Only for the 100% American product (Case V), without any foreign content whatsoever, the product cost in the American market remains uninfluenced by the

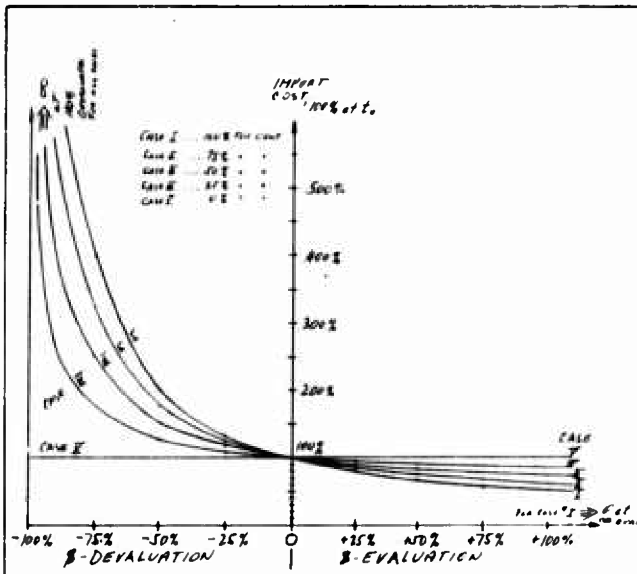


Figure 7 IMPORT DRIVEN COST

change of the exchange rate. In all conditions of a Dollar Evaluation, the costs go down asymptotic to the domestic content cost with inifinite evaluation and, of course, to zero for the imported 100% product.

Specific cost behaviors are illustrated with a few examples in Figure 8. Example #1 represents the cost for a 100% foreign product, originated in the NON-dollar area and imported in the U.S.A. after a 70% dollar devaluation. Example #2 represents the cost at time $t_i$ for an "American product" with 100% cost at $t_o$ and a 65% foreign content at time $t_o$. Example #3 portrays the import cost for a 100% foreign product after a 70% dollar evaluation. Finally, example #4 represents the domestic cost of an American product with a foreign content of 65%, measured at time $t_o$. The examples #1 and #3 can be considered as symmetrical with regard to inputs; so can examples #2 and #4.

An important point to be noted is the change of the penalty/benefit ratios between Example #1 over Example #3 (233/41) and between Example #2 over Example #4 with (143/28). In the first case, the ratio is 5.7 and 5.1 in the later case.

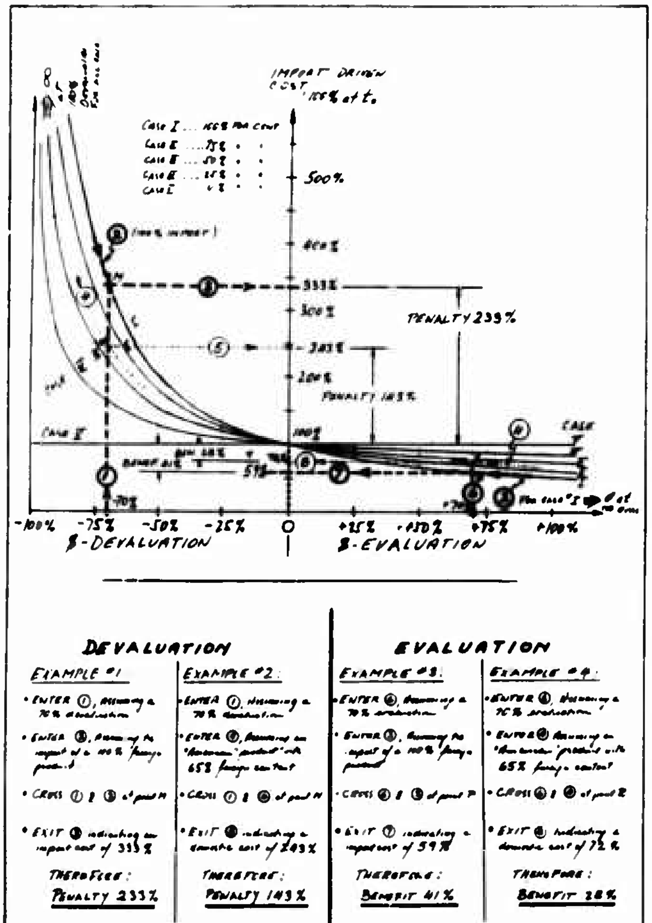


Figure 8 EXAMPLE OF IMPORT COST

The interpolation of entry #4 in Figure 8 between Case #II and Case #III may lack precision. We can trade-off the explicity of Figure 8 for exactitude in usage by using only the curve for Case I and read Exit #3 and Exit #7 with 333% and 59%, respectively. With this we can enter Figure 9, interpolate linear entry #4 and read off the results of Exit #5 and #8 with 243% and 72%, respectively.

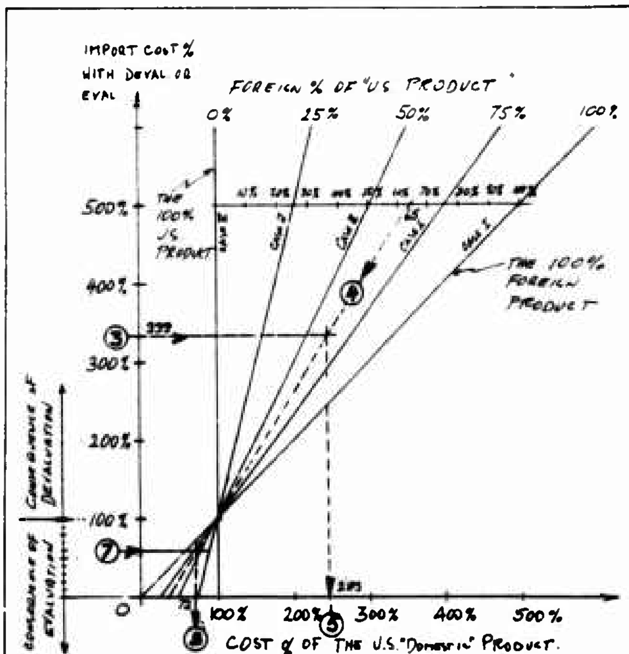


Figure 9 FOREIGN CONTENT AND IMPORT COST

## FROM COST TO PRICE

In the two foregoing sections, called the "domestic cost" and the "import cost," we discussed benefits and penalties of cost separately for both cases. No attempt has been made to combine these two behavioral patterns toward a joined cost picture. The reason why this joint-cost picture has been avoided is given by the fact that, for example, cost savings in the NON-dollar area (i.e., in Japan for a Japanese product) does not have to be reflected in a price reduction of such product in the domestic market of the NON-dollar area (i.e., in Japan). In short, we must shift from cost to price to connect the cost benefits and penalties for products originated in the NON-dollar area and thereafter imported into the dollar-area.

There is a logic in cost and a logic in prices; only these two logics are not the same. The only necessary connection between the cost-logic and the price-logic is given from the manufacturer's point of view by the statement, "the sum of all prices for a set of manufactured goods must be greater or at least equal to the sum of all costs." All other apparent connections between the cost-logic and the price-logic are optional, based upon a decision process, expressing the manufacturer's preferences. For example, a Japanese car manufacturer may decide not to pass his benefits (or savings) from a U.S. dollar devaluation into the domestic Japanese market in the form of a price reduction; he may decide to use his savings in order to subsidize his export price to the United States with the intent to preserve his American market share. But, the degree to which he can pursue this policy will depend upon the benefit-penalty ratio for his product in his domestic market and in the export market.

## Benefits/Penalty Ranges

The concept of the benefit/penalty ranges is sketched in Figure 10. In this figure, the related benefit/penalty ranges are shown for a devaluation of 40% and an evaluation of 30%.

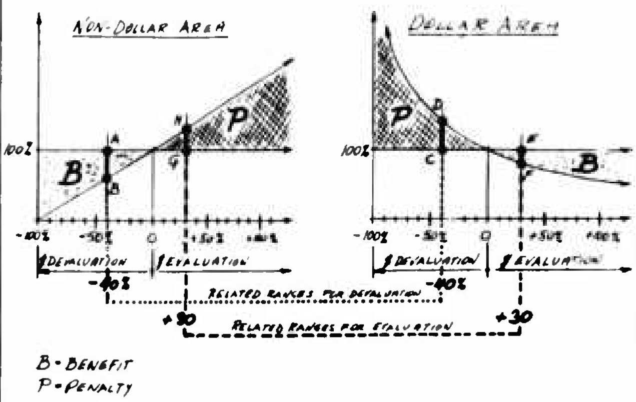


Figure 10 BENEFIT/PENALTY RANGES

Reading Figure 10 highlights the selected "analytical definition" and the meaning of devaluation and evaluation of the U.S. dollar for products originated in the NON-dollar area and also for products originated in the dollar area:

- o DEVALUATION means a BENEFIT for the NON-dollar area and a corresponding PENALTY for the dollar area.
- o EVALUATION means a PENALTY for the NON-dollar area and a corresponding BENEFIT area for the dollar area.
- o The sizes of the corresponding benefit and penalty ranges are different.

Next to the above "analytical definition: of benefits and penalties, many "subjective definitions" would be possible: an importers definition might be the opposite from an exporters definition and an American traveler to Europe will have a different judgement about benefits and penalties from a Japanese traveler to the U.S.A. Mixing the analytical definition with subjective definitions can perfectly confuse the issue.

The Figure 10 shows that for every specific devaluation (i.e., 40%) a range of benefits exist (Point A to Point B) for the product originated in the NON-dollar area; at the same time a corresponding range of penalties exist (Point C to Point D) for the export of those products into the dollar area. It also shows that for every specific evaluation (i.e. 30%) a benefit range exists (Point E to Point F) for imports into the dollar area; at the same time, a corresponding range of penalties exist (Point G to Point H) for exports from the NON-dollar area into the dollar-area.

A comparison of benefits and penalty ranges for selected percentages of devaluation and evaluation of the U.S. dollar is shown in table IV.

TABLE IV. BENEFIT PENALTY RANGES

| | BENEFIT RANGE FROM - TO | PENALTY RANGE FROM - TO |
|---|---|---|
| DEVALUATION | | |
| - 25 % | 0% - 25 % | 0% - 33 % |
| - 50 % | 0% - 50 % | 0% - 100 % |
| - 75 % | 0% - 75 % | 0% - 300 % |
| - 100 % | 0% - 100 % | 0%-INFINITE |
| EVALUATION | | |
| + 25 % | 0% - 20 % | 0% - 25 % |
| + 50 % | 0% - 33 % | 0% - 50 % |
| + 75 % | 0% - 43 % | 0% - 75 % |
| + 100 % | 0% - 50 % | 0% - 100 % |
| etc. | etc. | etc. |

An inspection of Table IV points toward the imbalance between benefits and penalties and toward the fact that the penalty range is always greater than the benefit range. Hence, deducting the benefit range from the penalty range would result in the net-penalty possibility for either devaluation or evaluation. In terms of macro economy, it may say that devaluation deters imports and fosters exports (from the U.S. point of view). Definitely a truth but of little consequence with regard to a specific product or to the managerial decisions for the exporting or importing companies.

## Benefit/Penalty Combinations

The concept of the benefit/penalty combination is sketched in Figure 11.

The example in Figure 11 is based on a 70% dollar devaluation. At the left side, we have the NON-dollar area and on the right-side the dollar area. The benefit range in the NON-dollar area goes from Point L to Point M. Point L would be, i.e., the 100% Japanese product without any content from the dollar-

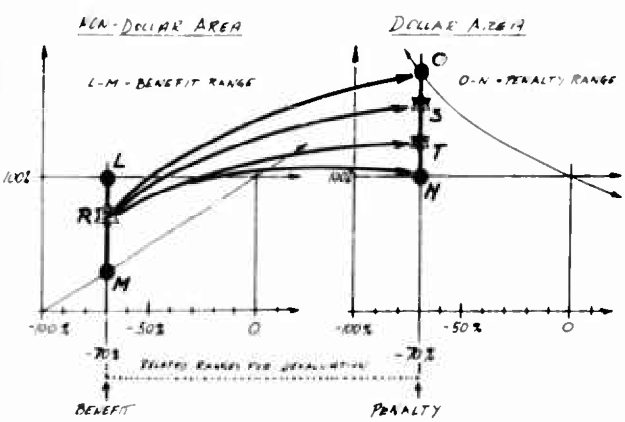

Figure 11 CONCEPT OF COMBINATIONS

area, and Point P would be a product that is completely (to 100%) imported into Japan from the dollar-area and, hence, has zero percent domestic (Japanese) content. A specific product, (made in Japan) might be represented by Point R; this product will have X% Japanese content and Y% foreign content imported from the dollar-area into Japan (i.e., resource materials). This product R, if imported into the U.S.A. can be an end-product (like a Toyota) and, hence, is represented by Point O. In the other extreme, the product R might be an entirely unimportant (measured in percent of cost) component for a practically 100% American product; in this case, it will enter the dollar-area at, or extremely close to Point N. The product R might also be a considerable component of the American product and enter the dollar area in Points S or T.

This example shows that the foreign-foreign content for the product of the NON-dollar area and the foreign content for the product of the dollar area are <u>independent</u> from each other and NO GENERAL STATEMENT OF THE INTERACTION BETWEEN THE BENEFIT RANGE (Point L to Point M) IN THE NON-DOLLAR AREA AND THE PENALTY RANGE (Point N to Point O) IN THE DOLLAR AREA IS POSSIBLE. ONLY PRODUCT SPECIFIC STATEMENTS ARE POSSIBLE, PROVIDED THE FOREIGN-FOREIGN CONTENT AND THE RELATED FOREIGN CONTENT IS KNOWN. IF THIS KNOWLEDGE DOES NOT EXIST, NO MEANINGFUL STATEMENT ABOUT THE IMPACT OF DEVALUATION OR EVALUATION IS POSSIBLE.

In order to gain insight into the possible spectrum of the benefit/penalty combinations, a series of combinations have been evaluated: All five cases for the foreign-foreign content combinations have been combined with all five cases for the foreign content combination and, thereafter, for each combination the benefit and penalty values were calculated for six different devaluations and five different evaluations. This total of 275 combinations is considered to be the minimum for the graphical delineation of the problem presented in this paper.

## <u>Parity Market</u>

The PARITY MARKET is <u>defined</u> as a single numerical indicator for the domestic market share a manufacturer in the benefit area must have, in order to compensate for the penalties in the foreign penalty area, whereby benefits and penalties are the consequence of changes in the exchange rate for the lead currency.

The above slightly convoluted definition needs discussion. However, the definition expresses clearly the search for a "simple number" that expresses the consequences for any combination of variables entering the exchange problem and, at the same time, to be of practical value to the industrial decision-maker, shifting from "cost" to "price" determination.

Figure 12 is the tool for explanation. The explanation is restricted to the case of the U.S. dollar devaluation. We assume the case of a manufacturer in the NON-dollar area (i.e., Japan) which sells this product to his domestic market and also as export to the dollar-area (i.e., U.S.A.). Once we consider this product to be an "end-item" in the export market; thereafter, we consider this product to be a "component" for an end-product made in the export market.

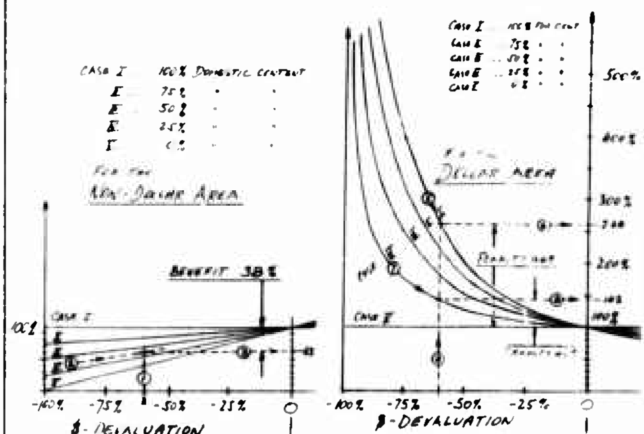

Figure 12 MARKET SHARE EXAMPLE

Entry #1 in Figure 12 assumes a devaluation of 60% and a foreign-foreign content of 35% for the manufacturer in the NON-dollar area. This means, for example, that a Japanese manufacturer who needs at the time $t_0$ 35% foreign content for his product, to be imported from the dollar area, will benefit with a 38% cost reduction because of the 60% dollar devaluation at a time $t_1$. As next step, we assume that our manufacturer is interested to export this product into the dollar-area (i.e., U.S.A.) as an end-product like a Japanese-made Toyota. We enter #4 and #5 in the right side of the figure and find with Exit #6 that this export (import) activity is burdened with a penalty of 164%. This means the price of the Toyota in U.S.A. "should" go up from, let's say, $10,000 to $26,400. This, of course, would mean the end of all exports of Toyotas from Japan to the U.S.A. However, it is an observed fact, that this is NOT the case: Toyota sells its cars in the U.S.A. after the devaluation almost for the same competitive price as before the devaluation. How come? Toyota gains on the domestic market a benefit of 38% and pays a penalty of 164% in the USA. Hence:

- The penalty ration P/B= 164/38= 4.32 which means that "if" Toyota does NOT pass on this savings into the domestic market, it can subsidize one export car with the gains of 4.32 cars sold domestically in Japan.

- If we translate the penalty ratio of 4.32 into percent (4.32/5.32), we find that Toyota needs a domestic market of 81% in order to export 19% of its production without price increase into the USA. Hence, the PARITY MARKET is 81.

- If the de facto domestic market is larger than the parity market, than a decision about the use of surplus benefit must be made, and if the de facto domestic market is smaller than the parity market, a decision about changes of the domestic and/or export prices must be made.

Now, let's go to the second part of the example of Figure 12 and assume we cross Entry #4 with Entry #7, which means that the export item from the NON-dollar area into the dollar area is only a 25% component of an American car, i.e., a HONDA, produced as "American" car in the U.S.A. Here we find at Exit #8 that the penalty amounts only to 42%. In this case:

- The penalty ratio P/B= 42/38= 1.11 (instead of 4.32 in the first part of the example). Hence, the Parity Market is 53.

- This means, HONDA, since it has itself established as a "domestic Japanese" car AND as a "domestic American" car can compensate for the cost penalties for its Japanese made components (and imported in the USA) with a domestic Japanese market share of only 53%.

To provide a general overview of the numerical behavior of the market parities, the result of the 275 trial calculations (with slide-rule accuracy) are summarized in Table V.

The parity market numbers of Table V are the basis of IF-games in the decision process for the price formulation. If, for example, the parity market can not be achieved, then it will not be possible to balance the penalty with the benefits in its own domestic market. If on the other hand, the parity market is smaller than the de facto domestic market, then it will be safely possible to balance the penalties with the benefits on the domestic market. The question can be asked about the size of the needed parity market in order to balance the penalties at different devaluation or evaluation rates, and so forth at infinitum.

TABLE V <u>PARITY MARKET NUMBERS</u>

| Nr | Percent of Domestic Content in Non Dollar Area | Percent of Domestic Content in Dollar Area | Benefit in Non-Dollar Area, Percent $ Devaluation: -100% (1) | -99% (2) | -75% (3) | -50% (4) | -[illegible]% (5) | -1% (6) | Benefit in Dollar Area, Percent $ Evaluation: +1% (7) | +25% (8) | +50% (9) | +75% (10) | +100% (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100 | 0 | 100 | 100 | 100 | 100 | [illegible] | 100 | 0 | 0 | 0 | 0 | 0 |
| 2 | 100 | 25 | 100 | 100 | 100 | 100 | [illegible] | 100 | 20 | 23 | 28 | 31 | 33 |
| 3 | 100 | 50 | 100 | 100 | 100 | 100 | [illegible] | 100 | 33 | 39 | 43 | 47 | 50 |
| 4 | 100 | 75 | 100 | 100 | 100 | 100 | 100 | 100 | 43 | 49 | 53 | 57 | 60 |
| 5 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 56 | 60 | 64 | 67 |
| 6 | 75 | 0 | 100 | 99.8 | 94 | 89 | 85 | 80 | 0 | 0 | 0 | 0 | 0 |
| 7 | 75 | 25 | 100 | 99.7 | 92 | 86 | 81 | 75 | 25 | 29 | 34 | 37 | 40 |
| 8 | 75 | 50 | 100 | 99.5 | 89 | 81 | 74 | 67 | 40 | 47 | 50 | 54 | 57 |
| 9 | 75 | 75 | 100 | 99.0 | 80 | 68 | 56 | 50 | 50 | 56 | 60 | 64 | 67 |
| 10 | 75 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 57 | 63 | 67 | 70 | 73 |
| 11 | 50 | 0 | 100 | 99.5 | 89 | 80 | 73 | 67 | 0 | 0 | 0 | 0 | 0 |
| 12 | 50 | 25 | 100 | 99.3 | 86 | 75 | 68 | 60 | 33 | 38 | 43 | 47 | 50 |
| 13 | 50 | 50 | 100 | 99.0 | 80 | 67 | 59 | 50 | 50 | 57 | 60 | 64 | 67 |
| 14 | 50 | 75 | 100 | 98.0 | 67 | 50 | 40 | 33 | 60 | 66 | 69 | 73 | 75 |
| 15 | 50 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 67 | 71 | 75 | 78 | 80 |
| 16 | 25 | 0 | 100 | 99.3 | 84 | 73 | 63 | 57 | 0 | 0 | 0 | 0 | 0 |
| 17 | 25 | 25 | 100 | 99.0 | 80 | 67 | 57 | 50 | 50 | 55 | 62 | 63 | 69 |
| 18 | 25 | 50 | 100 | 98.5 | 73 | 57 | 47 | 40 | 67 | 72 | 76 | 78 | 82 |
| 19 | 25 | 75 | 100 | 97.1 | 56 | 40 | 30 | 25 | 75 | 79 | 83 | 84 | 87 |
| 20 | 25 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0 | 0 | 100 | 99.0 | 80 | 67 | 57 | 50 | 100 | 100 | 100 | 100 | 100 |
| 22 | 0 | 25 | 100 | 98.6 | 75 | 60 | 50 | 43 | 100 | 100 | 100 | 100 | 100 |
| 23 | 0 | 50 | 100 | 98.0 | 67 | 50 | 40 | 33 | 100 | 100 | 100 | 100 | 100 |
| 24 | 0 | 75 | 100 | 96.2 | 50 | 33 | 24 | 20 | 100 | 100 | 100 | 100 | 100 |
| 25 | 0 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 100 | 100 |

The parity market numbers can be arranged in different ways in order to answer specific questions. The program manager in DOD with a program of high foreign content might be interested how a change in the exchange rate can influence the cost of his specific product; a trade negotiator might search for those particular products which are the most, or the least, influenced by the exchange rate changes in order to focus his attention on items with highest essentiality; the president of a multinational corporation might search for a corporate policy in order to decide what and where parts of his product shall be manufactured in order to be competitive on the world market. As different as those three specific questions might appear to be, in the concept they are identical. All want to know the benefit-penalty relationship as represented by the parity market number.

To answer any one, or better to work toward the answer to anyone of the above three questions, we may develop a simple purpose oriented worksheet as shown in Figure 13 and transpose the respective number from Table V into it.

The number in the worksheet (Figure 13) describes a surface: THE MARKET PARITY SURFACE for 75% devaluation. As illustrated, the market parity surfaces have been calculated for a devaluation of 75% and 25% and for an evaluation in the same percentages. Those four market parity surfaces are shown in Figure 14.

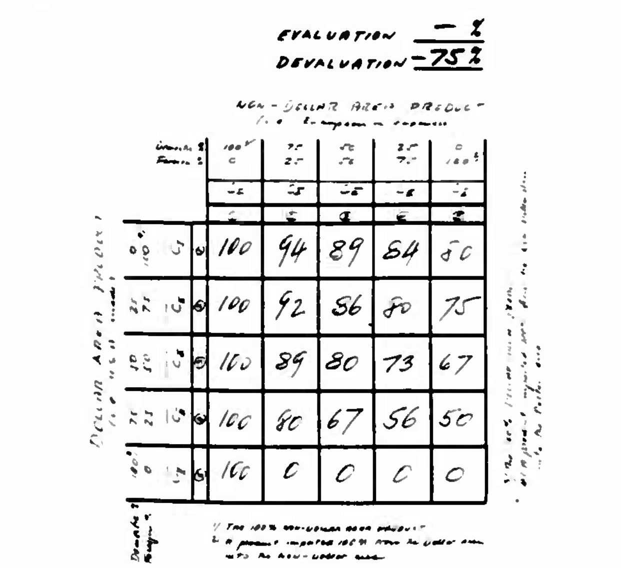


Figure 13 WORKSHEET FOR A SPECIFIC PROBLEM

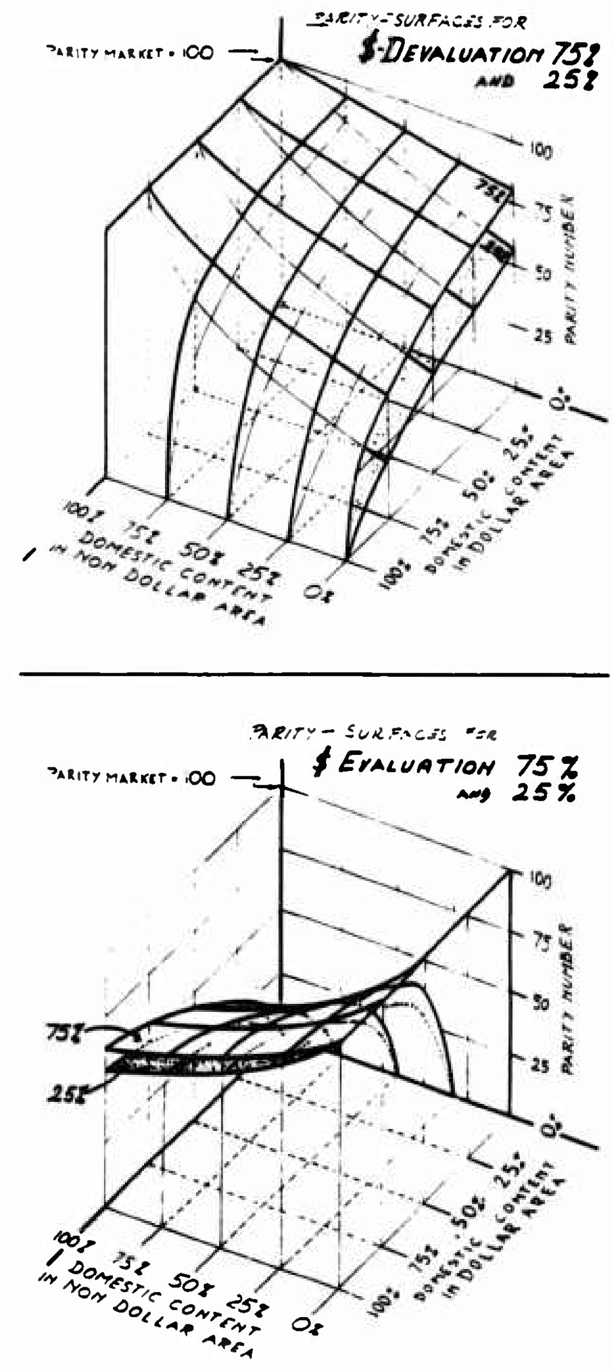


Figure 14 PARITY SURFACES

Now, we can construct for each surface the contour lines and project theme down into the base area of the content coordinates. This results in a reduction of the three-dimensional surface into a two-dimensional contour map of the market parity numbers for those specific surfaces. The contour maps for a 75% devaluation and a 75% evaluation of the lead currency, in our case the U.S. Dollar, is shown in Figure 15.

Every specific evaluation or devaluation has its own distinct parity surface and, hence, its own distinct parity contour lines and again, each specific case (as shown in the examples in the previous Figure 12) has its own specific parity numbers. A computer program is under development, permitting the practical application of the concept; it will permit us to use any change in the exchange rate to be combined with any foreign-foreign content and foreign content and printout the specific parity number and, also, graphics if so desired.

The example in Figure 15 reads as follows: In the upper part of the figure we have the case of a 75% devaluation and in the lower part the case of a 75% evaluation of the U.S. dollar. In both cases, we have the same Entries #1 and #2. Entry #1 says that our specific product, manufactured in the dollar area (i.e., U.S.A.) has a domestic content of 46%. Entry #2 states, that the part manufactured in the NON-dollar area (i.e., foreign) has, seen from the Japanese point of view, a domestic content of 70% which means that the other 30% (of the Japanese part) are imported into the NON-dollar area from the dollar area. Exit #3 shows the parity numbers for devaluation and evaluation, which means:

- In the case of a 75% devaluation, the benefits accrue in the NON-dollar area and the (i.e., Japanese) manufacturer in this area needs at least a domestic market of approximately 86% for his total output, in order to be able to compensate for the penalty by selling his product to the dollar area (i.e., U.S.A.).

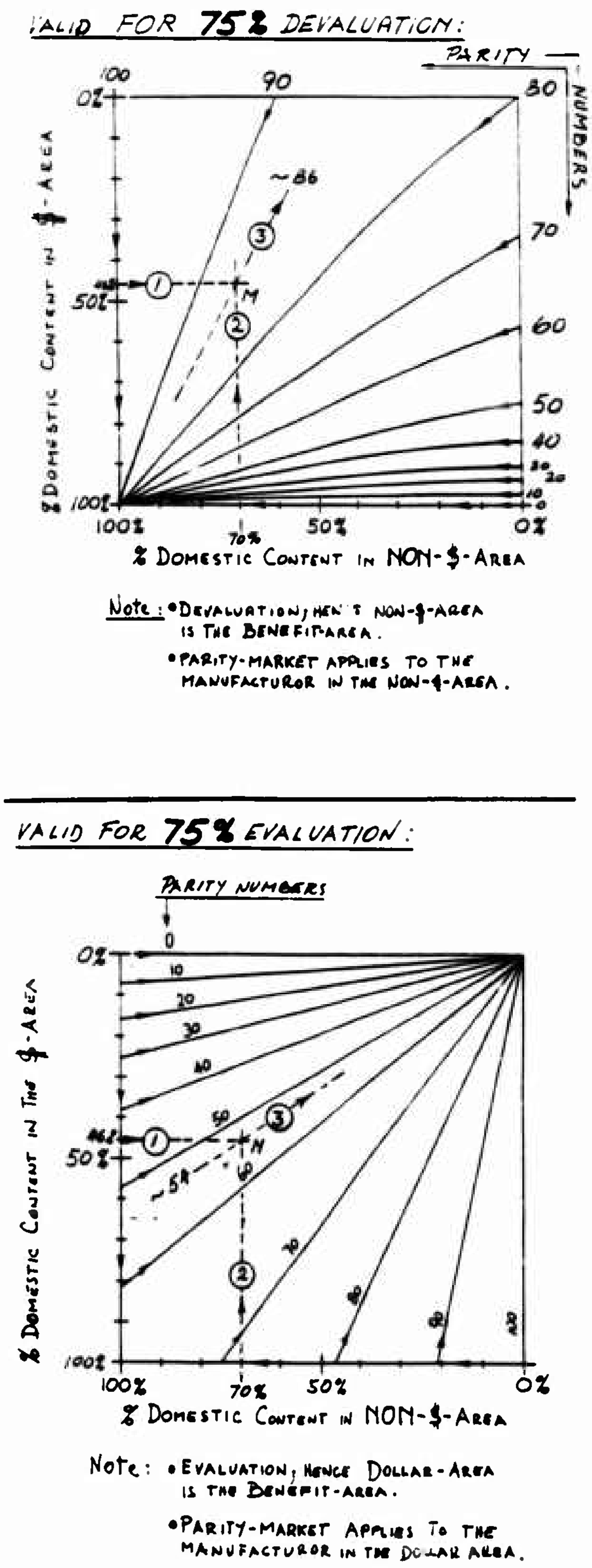


Figure 15 PARITY CONTOUR LINES

- In the case of evaluation by 75%, the benefits accrue in the dollar-area (i.e., USA) and the penalty hits the importer of foreign content into the NON-dollar area (i.e., Japan). In this case, the owner of the benefit area (i.e., U.S.A.) needs only a domestic market share for his products of approximately 54% in order to compensate for the penalty in the corresponding market.

The result of the example may be shocking. It seems to contradict the expectations, based on macroeconomic theory. However, the result is most understandable if one considers first the content relationship (of a specific product) of the two interacting markets and, second, the configuration of the interacting benefit and penalty areas (Figure 10 and 11); devaluation results in a linear behaving benefit configuration for the NON-dollar area and in a penalty area asymptotic to infinite for the dollar-area. In reverse, a relative small non-linear benefit configuration is associated with evaluation for the dollar area, to be balanced against a linear penalty configuration for the NON-dollar market.

## Price Decision

The pricing decision for a specific product, to be sold in the domestic or the foreign market, will have to consider a large number of variables. Accepting some artificiality, two groups of variables can be determined: first, the NON-CONTROLLABLE VARIABLES and, second, the CONTROLLABLE VARIABLES. The first are the subject in this paper, the second are not. Both sets of variables are sketched in Figure 16 and some will be outlined.

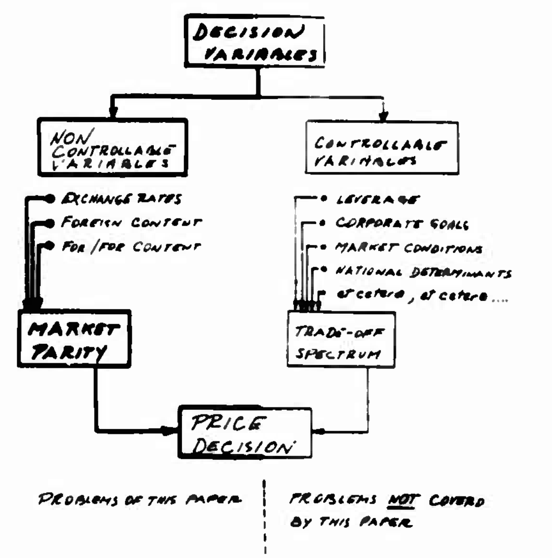


Figure 16 - VARIABLE FOR PRICE DECISION

The <u>non-controllable</u> variables are indicated with the heavy lines on the left half of figure 16. The exchange rate is definitely beyond the control of the industrial manager; the foreign content (in i.e., the U.S.A.) and the foreign-foreign content (in i.e., Japan) is not cast in concrete for all times, but definitely quite uncontrollable in the short-run. I would prefer to call the non-controllable variables the physical variables of the decision, whereby the exchange rate represents the tool of measurement and the foreign content and the foreign-foreign content the physical structure of the product.

The <u>controllable variables</u> are all those variables on the right side of figure 16. It must not be controllable in the strict meaning of the word; but they can be influenced at the corporate level, utilized or even bypassed. In short, they are those variables "one can work with." Some shall be called out: corporate goals, market conditions and national determinants.

<u>Leverage:</u> The power the supplier has over the buyer. Is it a necessary import or a convenience import, just nice to have it? Is it a single source or must the supplier compete with possible other sources? Does a long-term contract in dollars or yen or German marks exist? Will an exorbitant supply-price create competition? Is technological substitution possible? This is approximately the menu of questions a supplier will ask himself in the determination of the sales price for his product. There is NO general answer to those questions; the answers will be product-specific and can only be developed, if the foreign and the foreign-foreign content of a specific product is known.

<u>Corporate Goals</u>: Uncountable corporate goals might exist. But, they may all fall between two boundaries: profit or market penetration. If profit is the driving force, a manufacturer with a large domestic market in the NON-Dollar area might forego exports; if the export market, however, is needed to remain on the low end of the unit cost curve, the foreign manufacturer might trade-off profits against market penetration in the dollar area and price accordingly.

<u>Market conditions</u>: Will be different from country to country and from product to product. Market elasticity, market size and economic production quantity for different product, the relationship of the prime and the subcontractors and similar aspects will influence to individual price decisions.

<u>National Determinants</u>: Every business in the world must operate and execute its decision processes within the confinements of the national laws such as (just to mention a few): banking and credit regulations, competition and antitrust regulations, labor laws and tax structure and tax regulations. And here, at best we can divide the industrialized world into two "thinking-zones" but all aspects of uniformity crumble. The first thinking zone is the area of the common law (U.S.A. and G.B.) and the other is the world of the Code Napoleon (Continental Europe, Turkey and Japan). Just one extreme example: the arms length borrower/lender relationship in the U.S.A. is determined by the Glass-Stiegel Act of 1933, while banks and borrowers in Germany and Japan are strongly interwoven and the banks are an unofficial instrument to formulate national economic policy. As consequence, for example, a Japanese producer may be able to subsidize his exports from his domestic benefits and be protected from internal competition, while the U.S. manufacturer may have to be concerned with internal and external competition. In short, there are TWO DECISION WORLDS and plenty of differences within each world.

<u>Trend Summary</u>

The ongoing study reported in this paper is only concerned with the aspects of the concept. Only Scenario #3 of the area interaction (figure 1) has been analyzed with some completion. Therefore, it would be premature to talk about "conclusions" ready for publications in a text book. But, it is justified to substitute the term "general observations" for conclusions.

<u>Observation #1</u>: Product cost are following physical laws summarized in the market parity. Exchange rates and product contents are facts. They are the consequence of past decisions but, in itself, value-free. Hence, we have physical determinants.

<u>Observation #2</u>: Product prices are based on product cost, but subject to value-driven forces originated in the domain of politics. Accordingly, price decisions can be as diverse as value variations might exist. Hence, we have value determinants.

<u>Observation #3</u>: Macroeconomic theory is not designed to provide specific product oriented answers about the benefits and penalties because of changes in the exchange rates. Microeconomic observations for <u>all</u> products can practically not be collected. The development of a physical product taxonomy and a sample technique might be able to bridge the gap between macroeconomic theory and necessary microeconomic knowledge. (Work in this area is ongoing).

<u>Observation #4</u>: Cost trends as consequences of changes in the exchange rate are clear. They depend on the physical content of products. Price trends are at least fuzzy.

<u>EPILOGUE</u>

I opened Pandora's Box on the subject of exchange rates. I let the answer hang in the air: "It all depends"; the consequences might be good, they might be bad. Only on a product-by-product basis is a judgment possible. You have the right to call it heresy. But, before you do it, please re-read the foreword, where I told you what to expect: I expect your comments in the search for understanding of the phenomenon of exchange rates in order to develop a useful tool for the decision-maker in the military acquisition process.

# TRIANGULAR FREQUENCY DISTRIBUTIONS, AN OLD CONCEPT UPDATED FOR THE NINETIES

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## ABSTRACT

In writing NCMA's training manual on negotiations (2), the author tried to survey and incorporate the best of the current writings and thoughts on negotiations. However, what became readily apparent was that, while there was a great deal written on how to negotiate a position, there was very little on how to develop the various positions for a negotiation or just what were the reasonable and objective criteria to be used in resolving differences. There seemed to be little recognition of basic probability concepts or their implications for developing negotiation positions. Bottom line is that you can't realistically estimate, analyze, or negotiate "fair and reasonable" prices (or any significant contractual incentive arrangement) without addressing the underlying uncertainties or risks involved.

This paper presents a systematic approach for incorporating probability into negotiations. It uses a simple triple-entry approach (low, middle, and high estimates) and updates and extends the concept of triangular frequency distributions (TFDs). As an estimator, buyer, or auditor, you can use the developed model, a series of integrated spread sheet templates, to accurately cost model requirements and graph them for easy review. Then you can calculate the probability for a given cost (estimate) or cost for a given probability. If used by the parties to better understand the risks involved, it can greatly facilitate negotiations.

## INTRODUCTION

The buyer, in establishing a going in position with all the most optimistic estimates, is just as unrealistic as the seller using all the most pessimistic ones. Further, for the target or objective position, we sometimes instinctively choose the "most often" or mode position. This is frequently unrealistic because it doesn't consider the possible range of costs. A more rationale objective position is when there is an equal fifty percent chance of an overrun or underrun. Unfortunately, such "mean probabilities" or medians are determined by position and cannot be pyramided through the cost breakout to create a statistically valid "expected value" for the requirement. For example, the mean prob values for labor rates and the projected hours cannot be multiplied to get the mean prob value of the total labor costs; however, the arithmetic means of these two elements multiplied, would give you the arithmetic mean of total labor costs. While the arithmetic mean equals the mean prob (with a fifty percent of an overrun or overrun) for symmetrical distributions, they can vary nearly 5% of the range (high minus low estimates) for highly skewed distributions. In such situations, the mean prob may need to be determined as the last step in developing the objective position. Bottom line is that you can't realistically estimate, analyze, or negotiate fair and reasonable prices (or any significant contractual incentive arrangement) without addressing the uncertainties involved. The simplest way to do this is start with three estimates: (A) "Lowest Probable"--1 chance out of 100 it will be less than; (B) "Arithmetic Mean"--the middle position can also be input as "Mode" or "Mean Prob" and automatically converted by formula; (C) "Highest Probable"--1 chance out of 100 it will be greater than. (Statisticians out there will recognize that, for practical purposes, the above defines the spread between low and high estimates as 4.6 standard deviations for symmetrical distributions.) How you develop these estimates will vary with the situation. For the middle position, mode or mean prob estimates are generally developed through judgmental approaches and arithmetic means through statistical ones. Once you have these three estimates (low, middle, and high), you can develop a triangular frequency distribution.

## TRIANGULAR FREQUENCY DISTRIBUTIONS (TFDs)

Though the concept may be even older, it was at an Air Force Institute of Technology pricing course in the early seventies where the author was first introduced to the concept of TFDs. It was pointed out that for many real-world situations, the TFD with its area set to "1" represented data far better than a forced application of the standard frequency distribution (SFD). In retrospect, what was lacking at the time was modern personal computers with the software applications necessary to carry the concept further. For, combined with the power of a modern spread sheet such as Lotus 1-2-3 (c), this approach has the advantage of being simple to analyze by manipulating the area of a triangle formula, to graph and consequently to visualize and better understand complex relationships. Probabilities can be readily calculated from cost positions and vice versa. The first practical application of these updated concepts was the Subcontracting Incentive Contingency Reserve (SICR) Cost/Fee Model, currently being distributed by NCMA on a non-profit basis (3). Further research has shown that functions analogous to many advanced statistical techniques can also be accomplished. The TFDs can be "multiplied" and "added" as needed, with their uncertainty reduced mathematically in accordance with the central limit theorem.

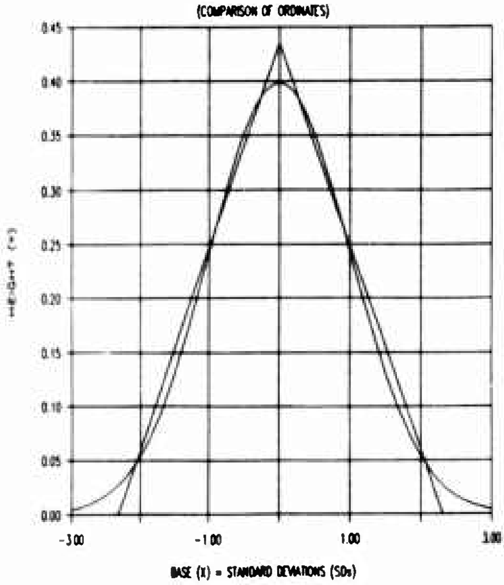
## SPREAD SHEET TRIANGULARS (SSTs)

All of these concepts have been incorporated into basic scratch pads (Lotus templates) for cost estimating, cost analysis, and negotiations, which NCMA is currently beta testing for possible contribution to the profession. For an introduction to these templates, which serve as the foundation for the following discussions, please now review the SST reference materials attached at the end of this article.

## UNDERLYING CONCEPTS

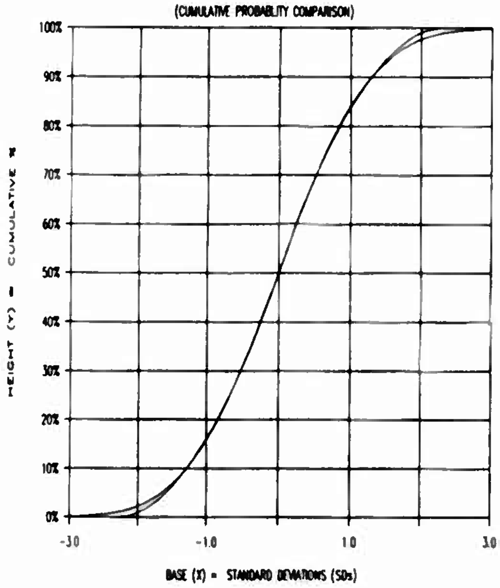
Figure 1 shows an overlay of the Standard Frequency or Gaussian Distribution (SFD) and a symmetrical Triangular Frequency Distribution (TFD). We used a standard text book ordinate table to determine height of the SFD curve (4), though it would have been possible to have calculated these values directly. Height

Fig. 1: TFD vs. SFD
(COMPARISON OF ORDINATES)



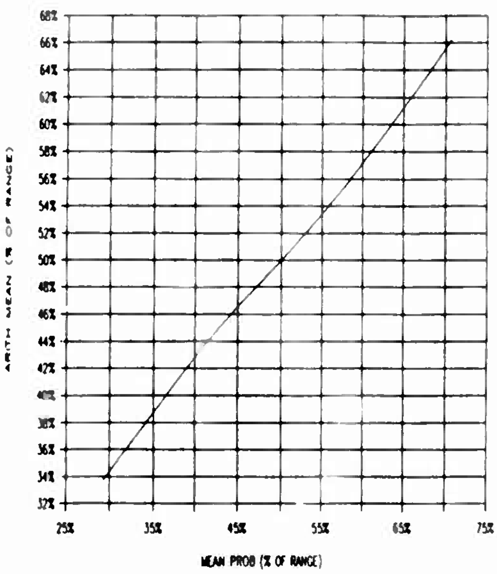

of the TFD, as most of our TFD calculations, was derived from the area of a triangle formula (area = 1/2 base * height). The area of each right angle was set at .5 and the overall base at 4.635 SDs, a constant for the symmetrical TFD. When these curves are represented as cumulative probabilities (areas) in Figure 2, it can be seen that the TFD gives essentially the same probability answers as the SFD to plus or minus 1.3 SDs. Beyond 1.3 SDs, its accuracy falls off rapidly showing 0% at -2.3 SDs (vs. 1.1% for the SFD) and 100% at +2.3 SDs (vs. 98.9% for SFD).

Fig. 2: TFD vs. SFD
(CUMULATIVE PROBABILITY COMPARISON)



For practical purposes, this translates to very accurate TFD calculations of probabilities between 10% and 90%. The TFD also handles non-symmetrical distributions better than many standard statistical approaches, as will be seen in reviewing the following graphs and working your own examples. Figure 3 illustrates the relationship of the arithmetic mean and mean prob (median) in TFDs. Interestingly, an arithmetic mean less than 33.7% or above 66.3% of the range (high estimate-low) or for the mean prob, 29.3% and 70.7%, are not possible. (Yes; they do total to 1.) These represent, at one extreme, where the low and mode are the same and, at the other extreme, where the mode and the high are the same. Obviously the mode can vary all the way between low and high estimates and, even at these extremes, the TFD can provide an accurate representation of the data.

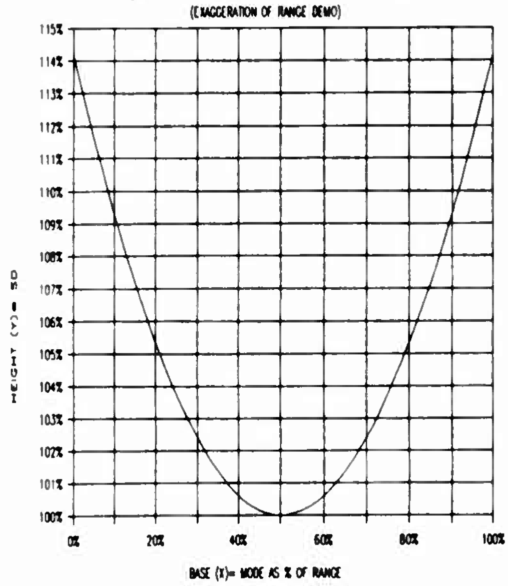
Fig 3: MEAN PROB vs ARITH MEAN




As indicated, the SD for a symmetrical TFD is the range (high estimate - low) divided by 4.635, or more precisely 4.6356847844. In terms of the SFD (and for estimating purposes), this means that for the Lowest Probable Estimate there should be one chance out of a hundred for the outcome to be lower, and for the Highest Probable Estimate , one chance out of a hundred for the outcome to be higher. In researching this area, we affirmed that the Standard Deviation (SD) is not a constant measure of dispersion. The SD is calculated for a population as the square root of the sum of the differences squared between the population values and the arithmetic mean divided by the number in the population. However, the arithmetic mean is the measure of central tendency most affected by extreme values; therefore, the SD as a measure is similarly affected. As illustrated in Figure 4, the calculated value of the SD increases as

Fig 4: STANDARD DEVIATION (SD)

(EXAGGERATION OF RANGE DEMO)




the mode shifts to the low or high extremes, even though the low and high extremes remain the same. (The relationship shown is for TFDs. A similar relationship should exist for all types of highly skewed frequency distributions.) Since the SD as a measure of dispersion varies depending upon how skewed the frequency distribution is, this had to be taken into consideration when developing our algorithms to add and multiply TFDs.

These developed algorithms use a stratified Monte Carlo simulation for TFD additions or multiplications. By stratified, we mean that each of the first or "top" TFD's 2% area increments are added or multiplied against all of the next TFD's 2% increments. This generates accurate simulations representative of a much larger random sample. With the 0% increment (since there's also a 100% increment) the simulation calculates 2,601 values, which are then sorted to determine the mean prob (median). The arithmetic mean is also calculated. As illustrated in Figures 5 and 6, given ratios or relationships exist between the arithmetic mean and mean prob of TFDs, which can be used to determine the new mode and, in turn, the new extremes (high and low estimates). This approach also has the advantage of automatically adjusting for the changing value of the SD and reconstructing a new "best fit" TFD. When you're running the algorithms, instructions are provided so you can actually view a comparison of the Monte Carlo simulation and a reconstructed TFD, similar to that shown in Figure 7.

Fig 5: DETERMINING THE MODE

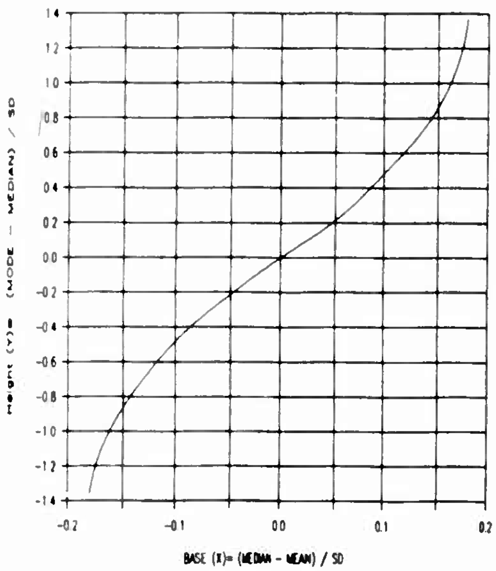
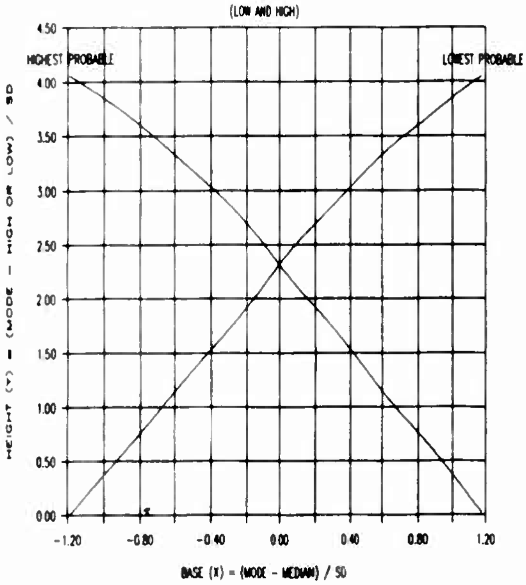



Fig 6: DETERMINING THE EXTREMES

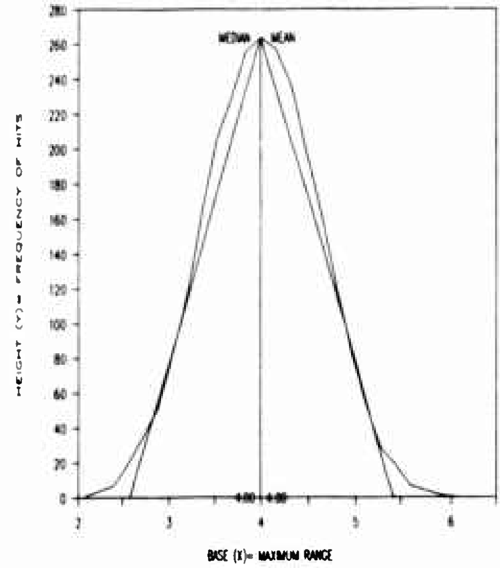
(LOW AND HIGH)




The Graph in Figure 7 depicts what happens when you add two symmetrical TFDs, each with low values of 1, arithmetic means of 2, and high values of 3. No surprises here and confirmation, in accordance with the central limit theorem, that uncertainty or risk has been reduced. The former low values added equal 2, but the addition algorithm indicates 2.6 as the lowest probable estimate for the added TFDs. Likewise, the former high values added equal 6, but the addition algorithm shows the highest probable estimate as 5.4. Just this one addition, assuming independence of the variables, has brought about a 30% reduction in the low to high range! (Equal magnitude, symmetrical TFDs were selected to accentuate the reduction for this addition example.)

Fig. 7: TFD ADDITION RESULTS

(MEANS EQUAL DISTANCE)




You get even more surprising results when TFDs are multiplied. Figures 8, 9, and 10 provide examples. In Figure 8, two TFDs, each with lows and modes equal to 1 and highs equal to 3, are multiplied. The expected skewed distribution to the right results, along with what turns out to be the largest uncertainty reduction (almost 40%). In Figures 9, two symmetrical TFDS are multiplied, each with lows equal to 1, modes equal to 2, and highs equal to 3. The simulation and TFD show a distribution still skewed to the right, though with lesser uncertainty reduction (almost 30%). The biggest surprise comes when we multiply two TFDs, each with lows of 1 and modes and highs equal to 3. While the TFD fairly represents the resulting simulation, it is not significantly skewed and little uncertainty reduction has actually occurred

Fig. 8: TFD MULTIPLICATION RESULTS

(LOWS AND MODES SAME)

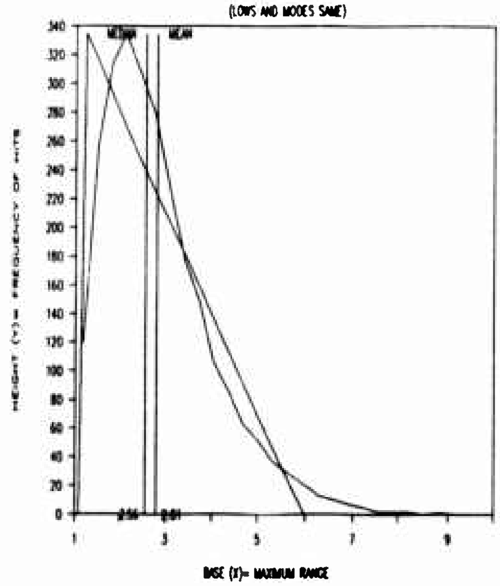


Fig. 9: TFD MULTIPLICATION RESULTS

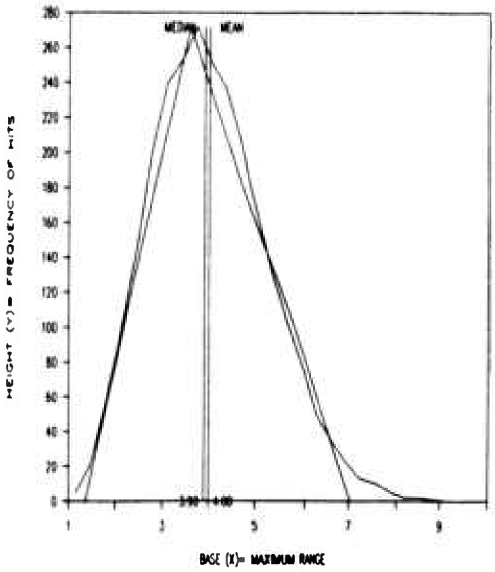
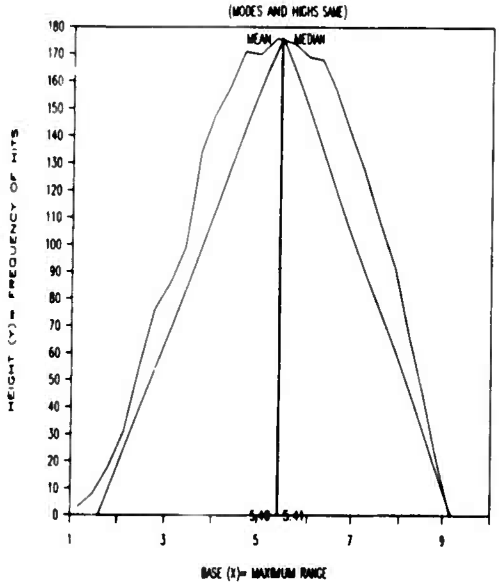



Fig. 10: TFD MULTIPLICATION RESULTS

(MODES AND HIGHS SAME)

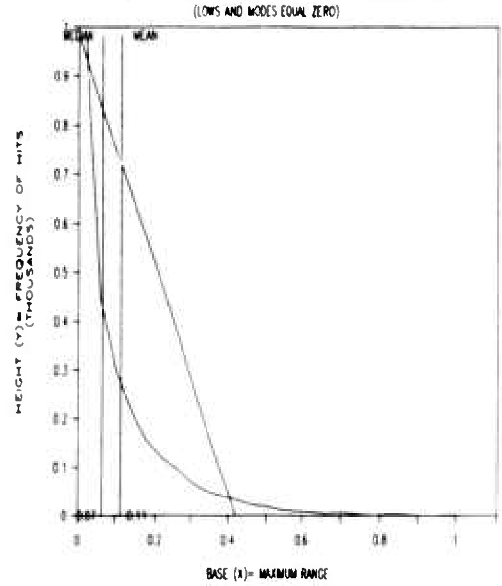



(about 5%). It appears that the preponderance of larger numbers being multiplied impedes the uncertainty reduction. We have kept the TFDs being added or multiplied identical only for illustration purposes. In the real world, the mode, magnitude, and ranges of the TFDs being added or multiplied will usually vary.

In some situations, usually when the low estimates are at or near zero as in Figure 11, the simulation may generate an arithmetic mean and mean prob beyond that which can be handled by a TFD. When this happens, the algorithm goes to its extreme adjustment, low estimate with mode the same. Since the correct arithmetic mean is automatically inserted when the data is called back from the simulation, the net result is that uncertainty reduction

Fig. 11: TFD MULTIPLICATION RESULTS

(LOWS AND MODES EQUAL ZERO)




may be slightly understated. Likewise, if for some reason the algorithm generates an estimate lower or higher than possible, it is also automatically adjusted to the limit when called back from the simulation.

A final area which needs to be addressed is dependent and independent probabilities. As examples, the cost of materials can affect direct labor and, in turn, the amount of direct labor can drive overhead. SST templates can address such dependent and independent relationships the same way that accountants and costs analysts do. The variable or dependent portion of the costs can be expressed as percentages of driver cost positions. The potential spread of fixed or independent costs can be calculated on the arithmetic mean of driver cost positions.

## CONCLUSIONS AND SUMMARY

In summary, NCMA's new SST templates are an integrated series of basic scratch pads for cost estimating, cost analysis, and negotiations. They integrate simple, conservative but very powerful probability concepts, which have the potential for significantly reducing the uncertainty (or spread) in cost or other estimates. They're designed to let you accurately cost model requirements, graph, and manipulate the data for easy review. If used by the parties to better understand the uncertainties involved, they can greatly facilitate negotiations.

What we need now are some hard-nose professionals to really put them through their paces and suggest improvements. Beta test copies of the templates will be available for interested participants at the 1989 Acquisition Research Symposium.

## Endnotes/Bibliography

(1) The SSTs were developed as an independent professional effort for potential contribution to the profession. As such, the opinions and concepts discussed are those of the author and are not necessarily those of AFSC or NCMA.

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# COST ISSUES

# COST ISSUES ASSOCIATED WITH TRUSTED CODE ACQUISITIONS

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## ABSTRACT

Computer security is a legislated requirement in all Department of Defense (DoD) computer acquisitions. A significant amount of effort is being expended to create security policies and to develop engineering skills in computer security. However, virtually no effort is being directed toward understanding the impacts of integrating security into a total systems architecture. The few existing secure commercial off-the-shelf (COTS) software products are not always suitable for providing adequate protection for many applications required by a secure computer system. There is, therefore, a need to develop trusted code for those instances. In addition, the Computer Security Act of 1987 requires all government agencies to address computer security risks, to develop computer security plans, and to implement a minimal level of computer security by 1992. This legislation ensures that the need to develop trusted code will only increase in the future.

This paper presents the preliminary results of a research project examining the applicability of commercially available software cost and schedule models for estimating trusted code developments. The first step in this examination involves a data collection effort where software metrics pertinent to trusted code development are collected from industry, Government, and academia. The data collection tool and process used to gather information are presented. Next, a security overview and a brief discussion of the software metrics pertinent to trusted code development are presented. The feasibility of calibrating (adjusting) three commercial cost and schedule tools to a trusted code environment is examined. Finally, the results of several calibration attempts are presented and their implications concerning the trusted code life cycle are discussed.

## INTRODUCTION

Computer security is a major requirement in most Department of Defense (DoD) and non-DoD procurements; it is legislated by the Computer Security Act of 1987 (Public Law: 100-235). By 1992, all military personal computers must conform to a minimal level of security as defined in Department of Defense Directive 5200.28-STD, also known as the Orange Book (1). A major consequence of this Act will be the need to develop specialized software known as trusted code. Trusted software ensures the protection of classified information from unauthorized disclosure, modification, or destruction.

Traditionally, computer security has been accomplished by providing physical and administrative system safeguards. This assumes that threats to private information come from outside the system boundaries. However, with the advent of distributed processing, distributed databases, communications networks, and requirements for specialized operating environments, physical safeguards do not always provide sufficient protection.

The types of systems examined in this research are secure computer systems that have trusted applications running on trusted operating systems.

## RESEARCH OBJECTIVES

The focus of this research is the calibration (adjustment) of software cost models to predict the impact of DoD security requirements on software cost. Although the methodology presented is DoD specific, it can be tailored to reflect a commercial development environment. This approach was selected for two reasons. One, classified information is clearly defined by DoD (Top Secret, Secret, etc.); whereas, the private sector has no general consensus concerning a uniform definition of classified information. Two, the DoD's computer security standards are the most explicit available.

This research project is predicated on the thesis that:

- There will be an increasing need to develop trusted code.
- Program management tools are needed to predict, monitor, and manage the trusted code development process.

## PROJECT OVERVIEW

Figure 1 graphically illustrates our approach to this project. The left side of the figure presents the current state of the art in software cost estimating. Most software cost estimation techniques are based on the traditional "waterfall" model of the software development process. This process is described through a set of measures or metrics which quantify various aspects of the development process and resulting software product. These metrics are correlated to cost, schedule, and/or effort using statistical analysis. Such analyses form the basis of many of the commercial software cost estimation tools available today, such as the G.E. PRICE Software Model, SPOR-20, Softcost-R, SLIM, and COCOMO.

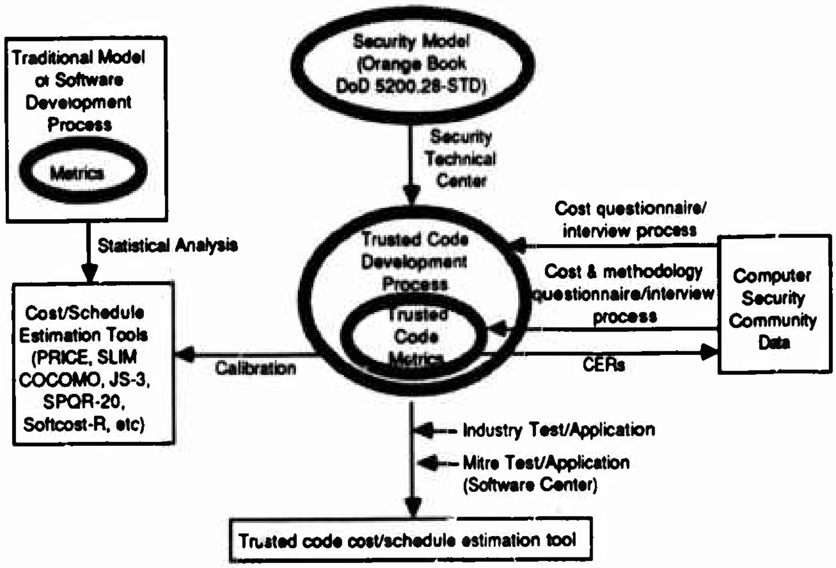


**FIGURE 1**
**PROJECT OVERVIEW**

Our basic approach (illustrated in the center of the figure) was to expand upon the traditional model of the software development process, by deriving a security specific trusted code development process model with its own metrics base. We accomplished this by applying our understanding of the Orange Book, enhanced by discussions with experts from the MITRE Washington Security Technical Center. The result was a draft version of a trusted code development process model which we used to calibrate the GE PRICE S model in 1987. This calibration was the basis for our FY88 draft trusted code cost methodology which has been documented extensively in the open literature (2,3,4,5). In FY89, we expanded our initial approach by instituting a trusted code data collection effort. We surveyed publications from the fields of cost estimation, software engineering, and computer security in order to determine a set of measures which quantifies the trusted code development process (see right side of figure 1). This set of metrics had to satisfy two requirements: 1) the measures had to be adequate to describe the security features of the software product, and 2) the measures had to be capable of providing input parameters for the models we would attempt to calibrate.

Once we determined a draft set of the metrics pertinent to both trusted code and the models of interest, we generated a data survey instrument or questionnaire. This was circulated to two sets of possible respondents: 1) a set of contacts in the computer security community, and 2) a set of contracts generated from a blind circulation of the questionnaire at the Fourth Annual Aerospace Computer Security Conference in December 1988. Nine questionnaires were returned, five of which had useable data. This was not sufficient to support an in-depth statistical analysis of the responses. However, we were able to use these responses to qualitatively refine the FY88 trusted code cost estimation methodology, and to examine the feasibility of calibrating three commercial cost and schedule models to a trusted code development environment.

## OVERVIEW OF COMPUTER SECURITY

The need for computer security is well understood although the way to achieve security and the impact it will have on system development cost is not always clear. Over the last several years the government has investigated techniques for developing trusted computer systems to protect computer software and data. There is no simple rule for creating such a system. To be trusted, a computer system must reliably enforce a specified policy for accessing the data it possesses while it accomplishes the functions for which it was built. (6) Some trusted systems are subjected to formal development techniques and stringent testing procedures to ensure that they function correctly. (1)

### Security Criteria Classes

At the beginning of a trusted code development, a risk analysis of the planned system is performed to identify threats to the system and potential system vulnerabilities. The results of the risk analysis are used to develop an initial set of security data requirements which is an input to a system decision paper. Then, a project plan is developed and quality assurance controls are outlined. At that point, a set of fundamental security requirements is identified. These requirements are developed within a framework of security criteria which ensure, to some degree, the integrity of classified information maintained by the computer system.

The Orange Book groups security criteria into four hierarchical divisions: D, C, B, and A. These divisions are further divided into classes. In order of increasing security protection required, the classes are: D, C1, C2, B1, B2, B3, and A1. We have identified the criteria class as the primary cost driver in trusted code developments. These classes are briefly defined as follows:

1. D - Minimal protection is provided.

2. C1 - Access is limited based on a set of system controls accountable to the individual user or groups of users.

3. C2 - Individual access controls are more sophisticated. Users are individually accountable for their actions through login procedures, auditing of security-relevant events and resource isolation.

4. B1 - In addition to C2 requirements, data labeling and mandatory access control are present. Flaws identified by testing are removed.

5. B2 - The system is segregated into protection-critical and nonprotection-critical elements. The overall system is resistant to penetration.

6. B3 - The system excludes code non-essential to security enforcement. Audit capability is strengthened. The system is almost completely resistant to penetration.

7. A1 - The system is formally verified via a mathematical proof.

The higher levels of trust outlined here actually implement few additional security mechanisms. Instead, they introduce additional verification and distribution controls to enhance configuration integrity.

Security Operating Modes

At present, three security operating modes are used to describe the operating environment of systems that process classified information. They are defined as follows (1):

1. Dedicated Mode - All system equipment is used exclusively by that system. All users are cleared for and have a need-to-know for all information processed by the system.

2. System High Mode - The system is cleared to one level of security. All users accessing the system have obtained this level of clearance at a minimum. All information on the system is maintained at the system level of clearance, even if the information is unclassified. No information at a clearance level higher than the system clearance level is stored on or processed by the system. All system output must be marked with the highest security classification of the material contained in the system.

3. Multi-Level Security (MLS) Mode - Various categories and types of classified materials are simultaneously stored and processed in a system. This permits selective access to the material by uncleared users and users with varying security and need-to-know clearances. Separation of personnel and material is accomplished by the operating system and associated system software.

DATA COLLECTION PROCESS

Our research involved a data collection activity focused on several data categories: a profile of the organization, project-specific data, and security specific data.

The profile of the organization provided demographic information including: a description of the type of business organization, size by annual revenues, size of the software development portion of the organization, percentage of business base dealing with government contracts, percentage of business base dealing with trusted code development, and the organization's level of experience with trusted code development.

Project specific information provided us with an understanding of the project. Its measures included: the identification of the primary user of the software (DoD, Government non-DoD, Commercial), the status of the program, and the data needed to calibrate existing software cost models.

Security specific data allowed us to identify metrics associated with trusted code development including: the operating mode of the software, accreditation level, familiarity with the Orange Book, clearance level of the developers, and clearance level of the system users.

COMMERCIAL MODEL APPLICABILITY

Industry data was used to investigate the applicability of several cost models for trusted code cost and schedule estimation. The models examined were: SPQR/20 from Software Productivity Research, Inc.; Softcost-R from Reifer Consultants, Inc.; and, PRICE S model from G.E. PRICE Systems.

We were unsuccessful in calibrating either SPQR/20 or Softcost-R to a trusted code development environment. SPQR/20's internal calibration feature was not sufficient to allow such an extensive calibration, and Softcost-R's internal calibration caused model execution errors since the costs exceeded the model's built-in limits.

Although the cost of trusted software was outside the bounds of both SPQR/20 and Softcost-R, we were able to calibrate the PRICE S model. Model inputs dealing with reliability, complexity, operating environment, organizational experience, and software size were adjusted using industry data as a guide. The specifics pertaining to PRICE S model calibration are being prepared for publication.

## COST RESULTS

Figures 2 through 6 show examples of applying the calibrated PRICE S model for the following five system application types: Management Information Systems (MIS), Data Base Management Systems (DBMS), Real Time Command and Control, Communications, and Operating Systems. Costs are presented for each of the criteria classes described in the Orange Book; these costs are normalized to the cost of a system with no security requirements (Baseline). These sample curves illustrate a severe cost penalty for the B3 and A1 criteria classes.

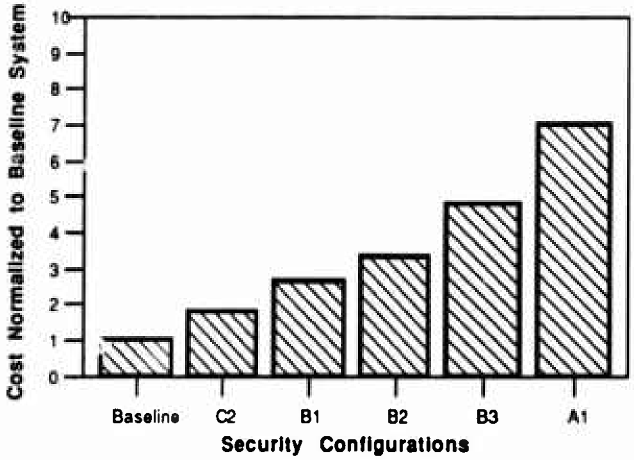


FIGURE 2
MANAGEMENT INFORMATION SYSTEMS

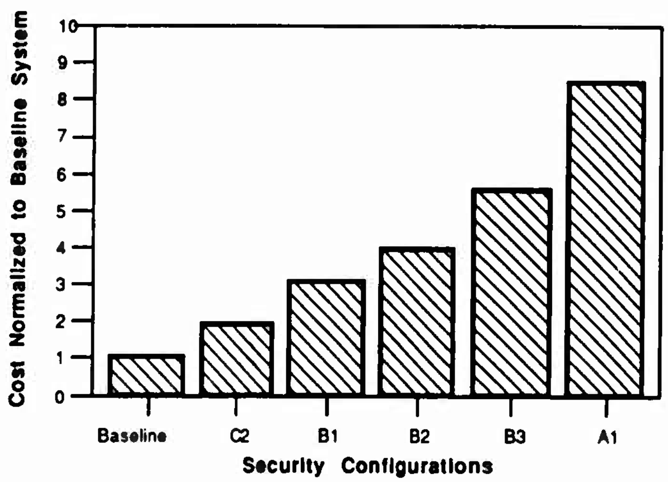


FIGURE 3
DATA BASE MANAGEMENT SYSTEMS

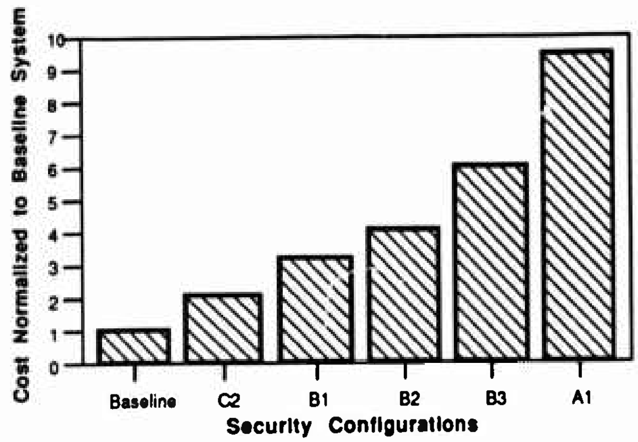


FIGURE 4
REAL TIME COMMAND & CONTROL

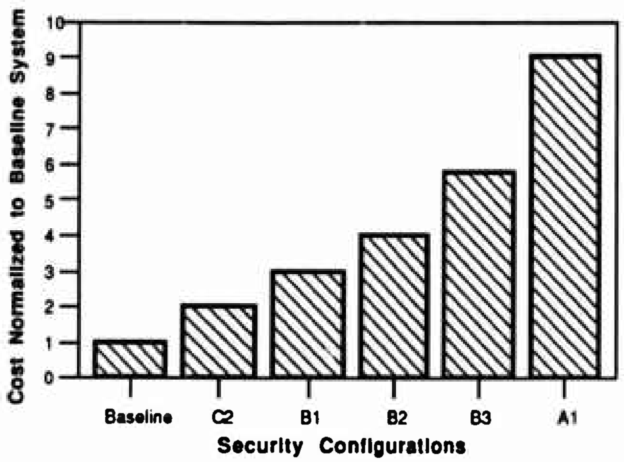


FIGURE 5
COMMUNICATIONS SOFTWARE

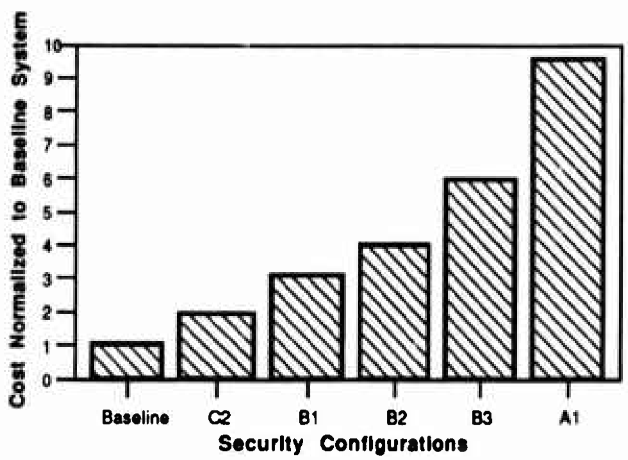


FIGURE 6
OPERATING SYSTEMS

## CONCLUSIONS/SUMMARY

Our research indicates that additional costs for secure software are distributed throughout the system life cycle. Specifically, more time must be spent in both the design and test phases. To develop a trusted system, security must be considered early in the life cycle since security mechanisms cannot be added to an existing design. The implementation language should have a well-understood, well-supported compiler. Additionally, the implementation language should be intentionally designed so that the programs can be verified. More formal system documentation is also required to demonstrate that specified security mechanisms have been implemented in the system. Moreover, there is more emphasis on configuration management. Some performance degradation may occur as the level of security features are increased; for time critical applications, this degradation may be overcome by providing more powerful (more expensive) system hardware. More time must be spent in the testing phase, especially if the software is expected to perform at the A1 level. The formal, mathematical proof required at the A1 level is a time intensive activity. Intuitively, software maintenance costs should be reduced since the software is thoroughly tested in the development phase. However, any enhancements in the maintenance phase of the life cycle will require stringent testing and possibly recertification of the whole system.

Finally, it is imperative that program managers of secure software system developments share cost and schedule information with the cost estimation community. Techniques for costing secure products can only improve as communication between the two communities increases.

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# FINANCIAL MANAGEMENT AND BUDGETING

FINANCIAL MANAGEMENT AND BUDGETING

## BUDGET PROCESSES AND DEFENSE ACQUISITION

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### ABSTRACT

Funding instability is one among the many problems that a program manager has to face in trying to deliver weapon systems on schedule and at or below cost. In fact, funding instability has been blamed for both schedule slippages and for the resulting cost growths. The problem, while widely acknowledged and discussed, has seldom been defined with precision, nor quantified adequately. [1] On occasion, funding instability has been discussed in terms of divergence between proposed Five Year Plan program funding and that actually obtained during the yearly budget submissions. On other occasions, budget instability has been attributed to congressional micro-management. In addition to its inadequate quantification, the problem lacks a clear theoretical framework to explain the mechanisms whereby budget instability translates itself into inefficiencies in acquisition. As a result, budget instability, while given visibility at the highest political levels, has failed to achieve credibility sufficient to secure effective remedial action.

The budget process is heavily tinged with political overtones. By contrast, efficient acquisition requires business-like attitudes and processes. This dichotomy is a the core of the budget instability problem: given our political and social structure, a clear cut solution seems our of reach (at least in the foreseeable future) but improvements are quite possible. In an effort to provide theoretical and factual underpinnings for such improvements, this paper discusses that portion of budget instability that arises from the budget process, and its impact on the cost of the weapons systems being procured. This is done by a cross-sectional study of selected appropriations and weapons systems for fiscal years 1988 and 1989. The first biennial budget provides unique insights into the budget process, specially since biennial budgets are being discussed as a step towards budget stability. After discussing the appropriateness of the data used, the study presents its findings and concludes that, while the existence of budget instability is supported by the data, its impact on the day to day acquisition process is less clear. Further data collection and a more rigorous and expanded study is needed to achieve the changes in the budgetary process required to foster budget stability.


### INTRODUCTION

On 20 December 1988 the then Under Secretary of Defense for Acquisition, Mr. Costello, sent a letter to the President of the Senate reporting on the actions taken by the Department of Defense (DoD) to simplify its acquisition procedures. Among the items discussed, the letter qualified the FY 1988-89 budget as "a serious effort to promote stability and consistency in defense budgeting" and asserted that "the contribution of this recommendation to program stability will depend largely on the cooperation of Congress...DoD...will submit a biennial defense budget for FY 1990/FY 1991."[2] Unfortunately, the cooperation sought was not forthcoming in 1987, and stability was not achieved with that budget. Cooperation from the Congress seems still to elude us: the mood on the Hill does not seem to be much different today.

How does budget instability detract from efficiency in acquisition, and why would biennial budgets solve the problems associated with it? There are no straightforward answers to either of those questions. Budget instability has a definitional problem: it represents different things to different people. For former Secretary of Defense Frank Carlucci, budget instability meant lack of "steady, moderate funding growth" and "congressional micromanagement," which result in a weakened defense posture and in inefficiency of operations. [3] As this is a comprehensive definition, we will briefly analyze its two main components in setting the scope of the present paper.

presented to the Congress by the Department of Defense.

The yearly request for procurement funds (budget authority) for each service, as reflected in the President's budget in January, was routinely reduced by about ten per cent, with even larger reductions relatively frequent. When there were increases, they were provided on short notice, and the January formal request was ballooned by supplementals and amendments. No wonder inefficiency can result when this

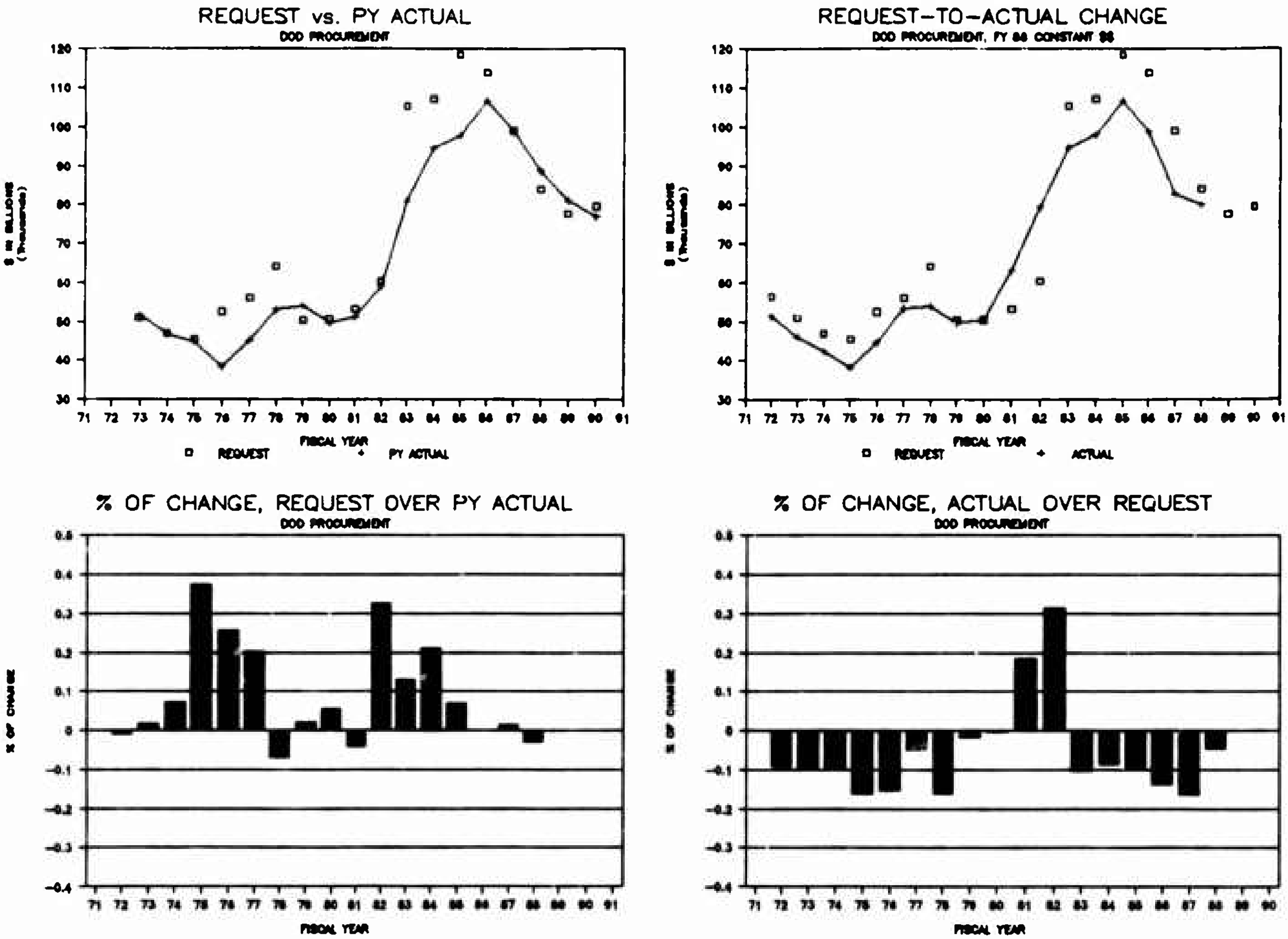


Figure 1. Changes to the procurement accounts, FY 1972-88
Sources: Budget of the United States
National Defense Budget Estimates.

## TOP-LINE FUNDING INSTABILITY

Figure 1 presents a compacted view of the instability problem: the procurement budget request often envisions relatively large increases over the funding received the previous year, only to see the request decreased again in the budget year. Figure 1 also shows very clearly how top-line instability is related in terms of annual increases and decreases to the estimates "instant stability" is superimposed over the long term funding and program instability inherent in our political and budget processes. The vagaries of the national economy, the uncertainty of the threat, and the lack of political consensus as to proper funding level for defense all conspire to preclude rational and stable long-term planning and funding.

It is apparent that profound--and

unfortunately unlikely--changes in the way that Congress conducts its business are necessary for the Department of Defense to obtain a guarantee of 'steady, moderate funding growth' spanning any long period of time. The constitutional mandate,[4] the doctrine of separation of powers, the short term tenure of legislators (and, for that matter, presidents) all conspire against a long term arrangement providing for such a commitment. In a pluralistic/adversarial political environment, a biennial budget would seem to be a more plausible alternative. But its gains in terms of potential congressional acceptability are obtained by maintaining a wishful approach to defense planning. Without a crystal ball to predict the economic and political future, the Service's planners have to assess the budgetary outlook optimistically to approximate a match with the foreboding future threat. DoD planners have to conduct long term planning in terms of assumptions that, year after year, are not met by the political realities of the budget.

Biennial budgets, then, have a better chance of gaining acceptance as a means of achieving a modicum of funding stability for the acquisition program. However, they need to be combined with the five year plan on which they are based--as recommended by the Packard commission--and spared congressional micro-management to be effective. Such a biennial budget would, if not solve all problems, at least ameliorate their severity. On the other hand, unless the biennial budget is accompanied by some understanding as to the continuing years, instability caused by lack of 'moderate, steady growth' and inability to accommodate within the yearly budget the Five Year Plan projections will continue.

It is for this reason important to examine our first try with biennial budgets, since its failure confirms the point just made. We must define the mechanisms whereby budget instability translates itself into inefficiency in the acquisition of weapons systems; we must examine how budget decisions affect the cost and schedule of our weapon systems. With that on hand, we'll be in a better position to press for reform.

## LESSONS OF THE FY 1988/89 BIENNIAL

The biennial budget of 1989/1989 was one more in the long list of years where practically no program escaped change, some being increased, most being decreased. If not representative, the biennial budget was at least typical in the amount and extent of the changes that it underwent.

Table I summarizes the top-line changes to the DoD biennial budget. The change in FY 1988 is measured from the budget submission in Jan 1987 (FY 1988 Estimate) to the budget submission in Jan 1989 (FY 1988 Actual). The change in FY 1989 is also measured as of those two dates, but shows one more data point which is the FY 1989 budget as amended by DoD in the budget submitted in Jan 1988. Thus the change in FY 1989 biennial has two components: the DoD adjustment, and the congressional adjustment.

BUDGET CHANGE FY 1888-89 (BIENNIAL)

| CATEGORY | % 1988 CHANGE | % 1989 DOD/CHG | % 1989 CONG/CHG |
|---|---|---|---|
| DOD | -0.064 | -0.101 | -0.002 |
| ARMY | -0.042 | -0.055 | 0.005 |
| NAVY | -0.012 | -0.096 | 0.010 |
| AIR FORCE | -0.114 | -0.078 | -0.027 |
| MILCON | -0.189 | -0.166 | -0.007 |
| MILHOUSE | -0.082 | -0.111 | -0.002 |
| MILPERS | 0.004 | 0.023 | 0.002 |
| OSD/OTHER | -0.867 | -1.066 | -0.868 |
| O&M | -0.052 | -0.049 | 0.003 |
| PROC | -0.047 | -0.154 | -0.010 |
| R&D | -0.165 | -0.137 | -0.016 |
| TOTAL | -0.064 | -0.101 | -0.002 |

Table 1. Changes to the Biennial budget. Sources: Financial Summary Tables and Budget of the U.S.

A few more numbers are necessary to complete the picture. The budget request for FY 1988/89 was $303.3 and $323.3 billion respectively. Budget actuals were $283.8 and $290.2, departing from a FY 1987 base, a program planned to increase by some $40 billion in the two-year budget barely gained $10, not enough to cover inflation. Acquisition took it on the chin: Research ad Development took consecutive hits of about 16 per cent, while procurement estimates suffered a relatively moderate 4 per cent cut in FY 1988, but a hurtful 15 per cent in 1989. Within procurement, as shown by Table II, the missile accounts were hit hardest, with the Shipbuilding account a net winner in reflecting the inclusion by the Senate Appropriations Committee of 2 replacement aircraft carriers not in the original estimate.

BUDGET CHANGE, FY 1988-89 (BIENNIAL)
PROCUREMENT BY CATEGORY

| CATEGORY | % 1988 CHANGE | % 1989 DOD/CHG | % 1989 CONG/CHG |
|---|---|---|---|
| AIRCRAFT | -0.118 | -0.044 | -0.021 |
| MISSILES | -0.219 | -0.220 | -0.071 |
| W&TCV | -0.027 | -0.083 | -0.050 |
| SHIPBLDNG | 0.432 | -0.230 | 0.044 |

Table II. Changes to commodity categories
Source: Financial Summary Tables

The first biennial experience did not provide any conclusive lessons. Congressional changes to its first year were typical; Congress did not address the second year. Based on those changes, and perhaps reacting to economic conditions and the perceived mood of the Congress, the Department reduced the original estimate for the second year to keep it roughly at the previous year's level plus inflation. Congress basically accepted this level when FY 1989 was resubmitted, but still made its customary changes to individual programs. Perhaps the most valuable lesson of the biennial budget process is that form will not substitute for substance. For biennial budgets to work, DoD/the Executive Branch and the Congress have to achieve a basic understanding and consensus as to the level of funding for both years, and a compromise as to how to minimize tinkering with individual programs. But this, we recall, was the budget instability problem as defined by Mr. Carlucci.

## THE INSTABILITY-INEFFICIENCY LINK

The Packard report stated succinctly the cause-effect relationship between budget instability and inefficiency in procurement: "chronic instability in top-line funding and, even worse, in programs...eliminates key economies of scale, stretches out programs, and discourages contractors from making the long-term investment required to improve productivity."[8] While this description is more appropriate for an inquiry into budget instability as a long-term trend, it still provides the basic ingredients for studying the effects of the budget instability generated by congressional micro-management and last minute DoD budget adjustments.

In essence, prices should remain constant, or decline slightly due to learning, if the conditions of production remain constant: the design stays unchanged, the rate of procurement does not change, and there are no changes to the producer's business base and workforce. Given a level of utilization at a producer's plant, decreases in funding that require decreases in quantity will nearly always result in increased unit costs, as fewer units share on the fixed costs of the production process.

By contrast, an increase in funding could have two opposite effects, depending on that given level of utilization. Ceteris paribus, an increase that can be accommodated within the production facilities in existence will decrease unit costs, for the reasons described previously; an increase that requires changes to the production facilities will produce in turn level or increased costs. Elementary economics, clearly, but necessary to interpret the outcome of the FY 1988/1989 procurement. Inefficiency in procurement (barring fraud and incompetence) has to be traced to inefficiencies in production. Thus the instability-inefficiency linkage is established as program change which impacts quantity which in turn impacts unit cost. We will look at the results of the budgetary process as it affects individual programs to try to evaluate this sequence.

## METHODOLOGY AND DATA

At the risk of boring readers with a procurement budget background, we should pause now and discuss two aspects of procurement budget the clarification of which will be helpful in the following discussion. The first is the budgetary structure of the procurement accounts, and its effect on the choice of methodology; the second is the physical layout of budgetary data and their availability.

There are four officially recognized "unit costs" for a weapon system.[9] Of interest here are the "Flyaway" and the "Weapons systems" cost. Recurring flyaway (and rollaway and sailaway) is the cost of the weapon system (let's say an aircraft) by itself. When engineering and other non-recurring cost (non-recurring flyaway) as well as trainers, publication, and ground support (support) are included, we arrive at the weapons system cost.

This is the cost that the yearly budget request (P-1) reflects: yet as a measure of the marginal cost of production of one aircraft or missile it is not accurate. The budget request for a given weapon system may fluctuate on a per unit basis quite independently of the cost of the weapon system itself. The budget request includes support for previously bought systems and non-recurring engineering for future procurement: the per unit cost of the budget request depends in part on the quantity of testers, trainers, and publications procured on that particular year. In other words, the unit budgeted cost of the weapon system may show an increase that, upon analysis, only reflects additional or increased procurement of support items with no change to the basic unit.

Unfortunately, while weapon systems costs are readily available, flyaway unit costs are not. Reasonably enough, the different exhibits prepared for the budgetary review of the different procurement appropriations are different in their physical layout, level of detail, and categorization of costs. This poses no problem for the budget examiners in DoD, OMB, and the Congress, since they deal with specific accounts and there is no need for across the board comparisons. The use of specialized exhibits may actually facilitate their review. Unfortunately, in a cross-sectional study those differences hamper collection and meaningful aggregation of data. In addition, detailed budget data is not widely distributed: it has been only in the last few years that level of detail has been officially furnished to Congress. Some of the budget exhibits are classified; still some others contain contractually sensitive data; in both cases data collection has to work around those problems. The end result is that it is extremely difficult to assemble a statistically valid sample.

The physical layout of the data and their availability largely determined the methodology and the scope of this study. Flyaway type data (marginal cost) were desired to ensure that quantity-cost relationships were not masked by the incidence of support costs. In practical terms, that meant that only aircraft accounts and missile accounts would be considered in the study, as they are the only ones the exhibits of which (P-5 and P-12, respectively) easily and accurately portray the recurring flyaway/support breakdown.

The study includes practically all Army, Navy, and Air Force aircraft (Aircraft Procurement, Army; Aircraft Procurement, Navy; and Aircraft Procurement, Air Force Appropriations) as well as most of the three services' missiles ( Missile Procurement, Army; Weapons Procurement, Navy; and Missile Procurement, Air Force.) A relatively few programs with classified or contract sensitive data were not included. In order to allow for a comparison of FY 1988 and 1989 (not included here) the data were further reduced to ensure that only items that were procured in both years were considered. All in all, the study includes 29 subjects, not a very large sample, but sufficient to test our previously stated hypothesis.

### FLYAWAY vs. QUANTITY

Tables III, IV, and V below depict the impact of the biennial budget process on the programs selected for study. In addition to those 29, of course, many more programs in these and other appropriations were affected by congressional or DoD action during the review and appropriation process. For example, in the 1988 aircraft procurement accounts the Congress denied Air Force's requests for AC-130 U's and C-27's, as well as Navy's request for ERCX. By contrast, DoD seems to have preempted Congressional action in the FY 1989 budget by taking out of the estimate items such as the A-6, the ERCX, the HH-60, (all Navy) and the C-27 and EH-60 (Air Force and Army). For our purposes, however, it is more important to concentrate on items that remained in the estimate and how they reacted to budgetary adjustments.

PROGRAM CHANGE, FY 1988
Request to Actual

| | | Total Funding | | |
|---|---|---|---|---|
| | | No Chg | Incr | Decr |
| Quantity | No Chg | 0 | 1 | 15 |
| | Incr | 0 | 3 | 3 |
| | Decr | 0 | 0 | 7 |
| Total | | 0 | 4 | 25 |

Table III. Changes in quantity grouped by budgetary action on program funding from budget submission to actual.

PROGRAM CHANGE, FY 1989
Request to Actual

| | | Total Funding | | |
|---|---|---|---|---|
| | | No Chg | Incr | Decr |
| Quantity | No Chg | 1 | 4 | 18 |
| | Incr | 0 | 1 | 1 |
| | Decr | 0 | 0 | 4 |
| Total | | 1 | 5 | 23 |

Table IV. Changes in quantity grouped by budgetary action on program funding from budget submission to actual.

PROGRAM CHANGE, FY 1989
Biennial to Request

| | | Total Funding | | |
|---|---|---|---|---|
| | | No Chg | Incr | Decr |
| Quantity | No Chg | 1 | 14 | 8 |
| | Incr | 0 | 3 | 1 |
| | Decr | 0 | 0 | 2 |
| Total | | 1 | 17 | 11 |

Table V. Changes in quantity grouped by budgetary action on program funding from biennial submission to budget (1989 budget) submission.

Two items jump at you from the above charts. First, the planned funding for every program was changed in every year (the "no change" in FY 1989 refers to two different programs: one was not changed by DoD from biennial to budget-amended; a different one was spared by Congress). Second, program managers were able to keep their quantity in spite of change in 71% of the cases.

Three reasons account for this remarkable resilience: in general terms, funding changes were relatively moderate; quantities are determined by the committees and established by law( 10 U.S. code 138 prescribes weapons systems that require quantity authorization); and procurement quantities are usually tied to force levels and operational plans. Given funding and quantity parameters, program managers seem to have prioritized and rescheduled support and other costs not related to marginal flyaway cost so as to prevent quantity-change related inefficiencies and the political and organizational fallout of not meeting Congressional or Services' schedules.

The 28% percent of programs that underwent quantity change as a result of funding change behaved, as a group, in a manner that supports the funding-quantity-flyaway cost linkage described before. The scatter plot in Figure 3 suggests that a linear relationship exists between the percentage change in quantity and the percentage change in cost for the weapon systems identified as

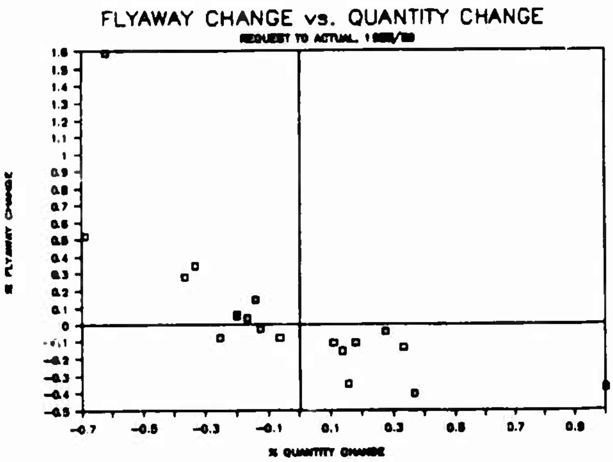


Figure 2. Percentage change in flyaway vs. percentage change in quantity. Source: Committee Staff Procurement Backup Books.

having quantity changes. Using least squares, the estimated linear regression equation for this relationship is:

$$Y = 0.0362 - 0.82774\ X$$

with a coefficient of determination ($r^2$) of 0.534.

It would be improper to consider the above computations as the final word in representing accurately the effect of budget adjustments on the flyaway cost of weapon systems across the board. It has previously been noted that the procedures used to assemble the data sample were chosen out of expediency, not scientific rigor. The regression line was estimated as linear, yet a second-degree polynomial regression function may have been more appropriate. The quantity cost relationship is properly assumed to be linear over a limited range but, since it is subject to diminishing returns over the long run, may well in fact be curvilinear.

Along the same lines, the quantity cost relationship is not as simple as the model depicts. The flyaway cost of a weapon system is affected also by several conditions/variables which were assumed constant in the simple model but have to be incorporated to increase its predictive value. Two obviously important variables, configuration changes and planning error, come to mind immediately. Changes to the weapon systems that do not explicitly change their model but increase their capability and their cost are quite frequent, almost commonplace. Then there is the impact of planning error, when the change disrupts plans and commitments already in process. The commitments on long-lead materials and work inherent in the concept of advance procurement (unique to each weapon system) will clearly contribute to the worsening of the effects predicted by the simple model. Quantity change and configuration change each will impact unit cost separately, even if concurrently. Planning error will impact cost as a conditional or intervening variable depending on the production trends and the amount and composition of the advance procurement for the particular system.

Incorporating those refinements into the model presents no unsurmountable problems. Larger samples and more inclusive procedures would, no doubt, produce substantive empirical evidence of the negative impact of budget instability.

## CONCLUSIONS

Budget instability has been with us for a long time, with roots that dig deep into our basic political structure: the budget process itself has been described as a 'struggle between the President and the Congress.'[7]

Internal DoD reform and improvements can go only so far (probably not very far) in solving it, or in mitigating its effects. Only political consensus can, realistically, solve the two problems of 'steady, moderate funding growth' and 'micromanagement' identified by Mr. Carlucci.

In our adversarial political system, ideas are accepted and consensus reached by putting them into the context of what the electorate will support. The electorate will support efficiency. It is therefore our task to present convincing, quantified economic evidence in making the case for budgetary reform.

That budget instability exists in its top-line form has been discussed and clearly established by many studies, including the present. Budget instability as nickel-and-diming of programs has not been as widely studied, and even less so at the level of weapon systems' marginal cost. There is no dearth of studies to support the need for change: there is however, a need for more study to establish quantitatively the cost of the current practices. Only when those costs are properly documented can long entrenched budgetary processes be expected to change and budget instability be reduced or eliminated.

## ENDNOTES/BIBLIOGRAPHY

1. The Selected Acquisitions Report (SAR) does not show budget instability as a determinant of cost change. See, for example, GAO/NSIAD-89-32FS WEAPONS COST: Analysis of Major Weapon Systems Cost and Quantity Changes, November 1988, Appendix I, p. 12 for a listing of definitions/categories of changes in program costs.

2. Letter, Office of the Under Secretary of Defense (Acquisition) to the President, U.S. Senate, dated 20 December 1988, "to report...on actions taken by the Department of Defense to simplify and streamline our acquisition procedures" page 24 of enclosure.

3. "Without steady, moderate funding growth we can neither protect our gains nor guarantee that our weakened defense posture can support our security commitments ...congressional micromanagement has precluded the Department from receiving the necessary level of defense resources on a timely basis...has often hindered our flexibility in allocating resources and executing programs in ways designed to improve efficiency and effectiveness." Annual Report to the Congress, Fiscal Year 1990, Executive Summary, p. 22.

4. Article I, Sections 8 and 9, of the Constitution of the United States gives the Congress the undisputed power to "raise and support armies" and "to provide and maintain a Navy," and prohibits "money to be drawn from the Treasury but in consequence of appropriations made by law."

5. A Quest for Excellence, Final Report to the President by the President's Blue Ribbon Commission on Defense Management, June 1986, p. xxii.

6. DoD manual 7110.1-M, the DoD Budget Guidance Manual, provides definitions of Flyaway, Weapon System, Procurement, and Acquisition unit costs as an increasing sequence where the cost of support, spares, and R&D and MILCON are added sequentially to that of the basic item.

7. See, for instance, Howard E. Shuman Politics and the Budget: The Struggle between the President and the Congress, (Englewood Cliffs, New Jersey: Prentice Hall, 1988)

8. Financial Summary Tables, Department of Defense Budget for Fiscal Years 1988 and 1989, 1989, and 1990 and 1991, Office of the Assistant Secretary of Defense (Comptroller)

9. National Defense Budget Estimates for Fiscal Year 1988/1989, Office of the Assistant Secretary of Defense (Comptroller) May 1987.

10. Committee Staff Procurement Backup Book, selected years and appropriations, Departments of Army, Navy, and Air Force.

# ECONOMIC ANALYSIS IN FEDERAL CONTRACTS: THE PROBLEM OF PRESENT VALUE

Robert E. Lloyd

## ABSTRACT

One of the consequences of the current budget deficit is that Government agencies are forced to make tough choices among programs competing for scarce dollars. A subset of this dilemma of establishing investment criteria is the choice between purchasing or leasing a capital asset. Current regulations on automatic data processing (ADP/computer) and telecommunications acquisition require that an economic analysis be conducted by comparing the discounted (present value) life cycle costs of these two basic alternatives. Unfortunately, the methodology prescribed for the lease-versus-buy decision is flawed, due to the false analogy that is drawn between public and private expenditure.

The current Federal guidance for calculating the present value of lease payments is analyzed, several inconsistencies in the underlying rationale are explored, and the case is made that there is little basis to discount for any factor other than expected inflation, if even that much can be justified. The result of the error in methodology evident in the present value analysis now used for ADP and telecommunications contracts is to favor leases inappropriately, which has increased the costs of programs under contract.

## INTRODUCTION

The source of present value analysis for ADP contracts is the Federal Information Resources Management Regulation (FIRMR; 41 CFR 201, June 1988), which directs in section 201-24.208(b) that the present value of money factor set forth in Office of Management and Budget (OMB) Circular A-94 must be included in comparative cost analyses, even though the Circular specifically exempts ADP acquisitions. The single discount rate (currently 10 percent) specified in the OMB Circular is deemed to represent the approximate long run opportunity cost of capital in the private sector. Using this approach, payments over time are adjusted to reflect the present value of these payments as of the date of contract award. For telecommunications contracts, FIRMR 201-24.305 requires basically the same analysis.

The FIRMR also states, in 201-24.208(a), that "the administrative cost of conducting an analysis to determine the lowest overall cost alternative shall be commensurate with the cost or price of the item being acquired and with the benefits to be derived from conducting the analysis." Nevertheless, most ADP and telecommunications acquisitions do feature a present value analysis (possibly for no other reason than that the regulation still requires this "commensurate" analysis). Present value analysis is an integral part of the General Services Administration's (GSA) Standard Solicitation Package for ADP equipment systems (Change 8, Section M.2.2; see FIRMR 201-32.204). It is important to keep in mind, though, that the "comparative cost analysis" using present value referred to in FIRMR 201-24.208(a)(1) is an analysis of alternative methods of acquisition, meaning offerors' pricing plans (lease, lease with option to purchase, lease to ownership plan, and purchase) for the same project, not a cost-benefit comparison of the desirability of spending money on one project versus another or the discounted value of the expected return for the amount of funds invested, which are the normal usages of the term.[1]

## HISTORY OF THE DISCOUNT RATE

The application of a present value discount for public projects is not new. In fact, the proliferation of interest rates used by Federal agencies in making investment decisions was a source of great concern in the late 1960's, which prompted a General Accounting Office investigation and ultimately led to the changes made to OMB Circular A-94 in 1972.[2] The choice of a rate is critical for the types of cost-benefit analyses that are performed before the Government initiates large capital investments such as construction of facilities, etc. Bearing this in mind, the Nixon Administration saw the use of a high discount rate as a means to reduce the palatability of public expenditures and thus indirectly to limit or reduce Government spending. Mikesell notes that in the early 1960's, "it is reasonable to suppose that a requirement that public projects produce an adequate yield would have resulted in the rejection of many proposed projects and therefore a reduced level of total government investment."[3] Hence the revision to OMB Circular A-94 made in 1972 chose a 10% standard rate, one which, at the time, was considerably higher than some of the rates being used by Federal agencies.[4]

The decision to use a 10% rate was based, in part, on a 1969 study of the average rate of return for the private sector, and the rate was selected as a measure of the opportunity cost of investment capital forgone, since "Government investments are funded with money taken from the private sector...and thus must bear an implicit rate of return comparable to that of projects undertaken in the private sector."[5] The rate has not been revised since 1972, despite the fact that the past 17 years have been some of the most turbulent economic times of this century, and today's economy is markedly different from that of 1972, particularly with regard to computers and telecommunications.

The budget implications of discounting are crucial, for the use of present value analysis is guaranteed to make leases seem more favorable in their pricing than an outright purchase. Not surprisingly, the increased use of lease plans in recent years has received wider attention. Alarmed at the presumably high financing rates reflected in monthly lease prices for ADP and telecommunications contracts, GSA proposed a Master Installment Purchase System (MIPS), which planned to separate the acquisition and leasing functions and offer agencies lease financing through GSA contracts awarded to financing companies at rates much lower than those which would normally be offered by ADP contractors. OMB, however, recognized the implications of this proposal and disapproved it. OMB argued that leases are inevitably more costly than outright purchase, due to the fact that agencies must pay the cost of the lessor's borrowing, which is always more expensive than Government borrowing in terms of the interest rate that can be obtained. In addition, financing schemes such as MIPS "encourage pork barrel spending."[6] Equipment leases, as OMB notes, can be used to "avoid front-end scoring of budget authority," whereas the guiding principle ought to be that leases "should be fully-funded and require sufficient budget authority to cover the full lifetime cost of the lease in the first year of the lease."[7] Thus we have come full circle to face the same problem of 1972 (how to reduce public expenditure), due at least in part to an improper extension of present value analysis to contract pricing plans.

## PROBLEMS OF SELECTING A DISCOUNT RATE

The discount rate selected can have a major impact on an acquisition, not simply by causing an award to be made to one firm versus another, but because, as Lind says, "if the discount rate is as high as 10 percent, the present value of costs and benefits in the future become insignificant compared with those of the present."[8] Unfortunately, the choice of an appropriate discount rate, or the use of a discount rate at all, is not a simple, mechanical task that can be done after a quantitative analysis of empirical data. In fact, the choice of a present value rate represents, by its very nature, a value judgment involving an exercise in applied welfare economics by the decision maker.[9]

Discounting for public projects has been the subject of intense debate among economists for decades. Few universal conclusions have resulted from the debate other than the fact that the choice of a rate reflects the personal views of the chooser. Sen's compelling analysis of the broader implications of selecting a discount rate concluded: "There is, in fact, very little scope for avoiding a deliberate ethical exercise in choosing appropriate rates of discount."[10] The reasons for this are multi-fold. When discounting costs over time, the first question that arises concerns the treatment of present versus future generations. To perform a present value analysis is to make an assumption about the value of money and the worth a current investment will have in the future. By leasing rather than purchasing, we are deferring some of our expenditures to future years, yet the preferences of future persons cannot be known; this has caused some to view any present value exercise as undemocratic.[11] Mikesell claims that future citizens will not be helped by increasing public projects at the expense of private investment, but only by a general increase in the level of investment across both sectors.[12] In any case, we cannot avoid uncertainty in the process, because the costs and benefits of public projects are unequally distributed and valued differently by different people.[13]

Sen notes the difficulty of deciding whether our postponement of spending can be justified in terms of our low welfare level as compared with that expected for future generations, and he poses the question of whether future generations can legitimately claim that we are taking something to which we are not entitled, merely because of the arbitrary fact that we had access to the resources before the future generation could; he concludes that the choice of a discount rate cannot escape such issues.[14] Sen further explains that, not only is the interpersonal weighting implicit in private interest rates different from the weighting used for public decisions, but the interpersonal distribution of sacrifices and benefits is not the same in different types of investment; "private and social rates of discount will differ depending on the interpersonal compositions of present consumption sacrifices and future consumption gains in the two types of investment."[15]

Because of similar concerns, Somers[16] believes that there is no "social discount rate," because only the decision makers, whether they are voters, elected representatives, or appointed civil servants, can place a value on the stream of future benefits of a project. Somers comments that a good public opinion poll would be more useful than a hypothetical discount rate, for the present value of future public goods is whatever the voters or decision makers think it is, and the search for a single discount rate applicable to all public investment will always be elusive. Some may argue that voters are ignorant of the relevant facts for such decisions, but Somers points out that only the voters can know their own preferences for present consumption over the future consumption represented by a public investment; to search for a proxy in the interest rate on Government bonds, or the private borrowing rate, or the opportunity cost of capital in the private sector is futile, especially since citizens may have different time preferences for different public projects, instead of the uniformity assumed in the Government's usual economic analysis.

## OPPORTUNITY COST

The FIRMR's rationale for using a 10% discount factor is that this allegedly represents the opportunity cost of capital in the private sector. The original purpose of economic analysis using present value discounting in public expenditure was to assist the Government in deciding between two or more available capital projects for funding and/or to require publicly funded projects to generate a return worthy of the investment, as opposed to leaving the funds in the private sector. Such discounting was never intended to be a mechanism for comparing pricing plans for contractor proposals on the same project for which the Government was already committed to funding; this may explain the explicit exemption in OMB Circular A-94. The public investment criterion is whether a project's funds can do more for society in implementing the public project than if they were left in the private sector and the project were not funded at all.[17]

At least one author has criticized the reliance on opportunity cost in such decisions, because private sector returns may not represent opportunity costs for the Government; if private investment opportunities are not the same as public investment opportunities, private rates of return are irrelevant for Government decision making.[18] In addition, it can be argued that the transfer of one dollar from the private to the public sphere may have more or less than one dollar in total capital formation depending on the yield of the public sector project. An alternative would be to use the social rate of time preference, but this technique is equally open to criticism.[19] One advantage proclaimed for the opportunity cost method is that there are observed rates of return available for use as a guide;[20] unfortunately, though, many ADP acquisitions are projects without private sector counterparts, so a proxy for the opportunity cost of capital must be developed.[21] More importantly, however, since there has been no adjustment in the rate used for Federal projects since 1972, one wonders whether the 10% discount rate was chosen for its empirical merit or its political value.

A present value analysis may have legitimate worth in comparing alternatives in a requirements analysis before the contracting process begins, such as that specified by FIRMR 201-30.009(a); this analysis is similar to traditional cost-benefit analysis, but regrettably the FIRMR also refers to this as a "comparative cost analysis," even though it is not the same type of comparison as that used for pricing plans. This requirements analysis approach to economic analysis can help decision makers explore feasible alternatives (with differing returns or benefits versus costs) for accomplishing required Governmental functions. In a larger sense, the usefulness of present value discounting comes at the point in the decision making process when the Government, including Congress, is deciding whether to fund a project or not to fund it (and thereby to reduce spending accordingly). The budget authority in making its decision to fund an ADP project should, if possible, look at the costs of the proposed project (e.g., automating a process now being performed manually) in comparison with the costs of not proceeding with the project (continuing with manual processes) and the attendant benefits; application of present value discounting is arguably appropriate in such cases to show what would happen over time if a project were or were not funded. To perform a present value analysis again when contractor offers are received for a funded project is not only redundant or double-counting, but, as we shall see below, detrimental. Federal agencies presumably issue solicitations only for projects that have been approved in a budget, so the present value analysis should have already been performed, as the Government has made its decision to acquire the equipment.

It is interesting to note that the FIRMR's opportunity cost methodology is not the only means used by the Federal Government to evaluate lease-versus-purchase arrangements. OMB Circular A-104, which presumably does not apply to ADP contracts because the A-94 rate is required instead, states that the discount rate to be used is the interest rate on new issues of Treasury securities whose maturity corresponds to the term of the lease.[22] This is the "cost of Government borrowing" approach, which has been criticized for implicitly regarding the sovereign as if it were a profit-maximizing organization,[23] thereby making the rate unrealistically low as compared to the cost of financing faced by private firms investing in projects. Overall, it seems incongruous for the same Government to employ two opposing views of how and why present value discounting should be accomplished.

Even more curious is the fact that FIRMR 201-30.009-1 states that, for acquisitions of $50,000 or less, the "comparative cost analysis" may be limited to an analysis that shows that the benefits of the proposed system will outweigh the costs, rather than the present value analysis required elsewhere in the FIRMR. In other words, the FIRMR considers a standard cost-benefit analysis to be equivalent to a present value comparison of pricing plans (lease-versus-purchase) in such cases, even though these are clearly two different types of analyses performed for entirely different purposes. This confusion reflects an underlying lack of agreement on both the economics of discounting and the role of the State in society.[24]

## PUBLIC AND PRIVATE SPHERES

In private industry, a lease may be more attractive than an outright purchase, since funds can be invested at compound interest or there may be alternate uses of the funds. In the Government context, however, budget line items restrict alternate uses of funds, and funds are not invested to reap interest. The standard textbook rationale for performing a present value analysis is fairly uniform among economists of all perspectives and is best summarized by Mishkin: "The concept of present value is based on the common-sense notion that a dollar paid to you one year from now is less valuable to you than a dollar today because you can deposit the dollar in a savings account and have more than a dollar in one year."[25] It is a false analogy to say that the Government should perform a similar analysis when it compares pricing plans for its already-budgeted expenditures. Buchanan, among others, is critical of this sort of effort: "Nonmarket choice cannot, by its very nature, be made to duplicate market choice....[P]roportionality between the decision-maker's cost-benefit matrix and that of the community will not ensure an approximation to market choice results in a regime of bureaucratic choice. Costs as confronted by the choosing agents must remain inherently different in the two decision structures, and it is these differences that constitute the basic problem of securing efficiency in nonmarket choice-making."[26]

Apart from the basic dilemma cited by Buchanan, and in addition to the fact that a cost-benefit analysis should have already been performed as part of the requirements analysis prior to the solicitation process, another defect of the present value technique is that the Government does not invest money to gain interest. The Federal Government is now a deficit economic unit and so has no funds to invest, at least when the Government is considered as a whole. Even if there were no deficit, the purpose of Government is not to maximize its own revenue. A surplus Government budget is a sign that taxes are too high or similar imbalances exist. It is true that the Government does, in fact, lend funds out at compound interest rates through the Federal Reserve Banks, but the purpose of the Federal Reserve System is not to generate interest income for the Federal Government, but rather to provide for a safe and flexible banking system.[27] Moreover, the interest that borrowing banks must pay accrues at the expense of the banking public.

A further argument in favor of present value discounting might be that the Government's acquisition of an item, to the extent that it represents an investment with some sort of return (a return-generating expenditure), should be evaluated to show the return as it related to costs. Unfortunately, the FIRMR states that the 10% discount rate is the presumed opportunity cost of capital in the private sector, not the amount of return expected from the public investment, and since many ADP applications have no private counterpart, it is illusory to compare the two sectors as equivalent. In any case, this sort of analysis should be made before the decision to include any funds for the project in the agency's budget. The matter is further complicated where the FIRMR addresses telecommunications acquisitions. FIRMR 201-24.305 allows agencies to use a higher discount rate for telecommunications contracts than that prescribed in OMB Circular A-94 "to reflect the agency's desired rate of return to assure the optimal allocation of its limited funds." The FIRMR fails to give any explanation for the inconsistency in treatment between ADP and telecommunications acquisitions, and this reveals a basic uncertainty about the purpose of discounting for present value in Federal contracts. It should be noted that using a higher discount rate makes telecommunications equipment leases seem even more favorable than outright purchase, even though such leases are more costly; the intent of this regulation thus appears to be more to promote telecommunications usage (and attendant spending) than to promote efficiency in public expenditure.

The obvious question that arises when the Government determines that (based on a present value analysis) it is cheaper to lease rather than purchase ADP, is what happens to the money in the current fiscal year's budget that would have been used for a purchase but is not spent now due to the supposed economic advantage of leasing. In an opportunity cost framework, the money would not be spent at all; instead, it would be saved for use in future years to pay for the lease costs of the out-years. In the Federal Government, this does not occur. Due to the predominance of one-year budgets and statutory restrictions on transferring appropriated funds from one fiscal year to the next (see 31 U.S.C. 1308, 1341), any money not obligated in the year of the contract award due to the use of a lease plan rather than a purchase plan is almost always spent in some other area, because otherwise it will be lost for the contracting agency's use,[28] which means that there is no real savings in opportunity cost terms, and overall spending is increased rather than reduced.

In other words, the premise of the opportunity cost model of discounting is that in cases where a project's costs outweigh its benefits, the project will not be funded and the intended funding will be left in the private sector. To superimpose this approach on the lease-versus-purchase decision process as the FIRMR does would mean that in cases where leases are more cost beneficial than purchase plans, the money saved each year by leasing would not be spent but would instead be left in the private sector (or the agency's budget reduced accordingly), yet this is clearly not the case. The money is simply spent elsewhere. The opportunity cost methodology of the FIRMR is therefore flawed in its basic premise. This sort of false economy is even more evident elsewhere in the FIRMR, at 201-32.102(d), where the regulation states that when purchasing equipment is in the best interest of the Government (based on a present value analysis) and purchase funds are not available, the contract may be awarded on the basis of a lease plan. To do this is to encourage uneconomical methods of acquiring ADP resources in the interest of obtaining more computers.

Even if the FIRMR methodology were appropriate, it would suffer from the measurement problems discussed in the economics literature; the search for an empirically sound discount rate has been summed up by Landauer as a "wild goose chase."[29] A unitary rate can hardly be applied across the board for all ADP projects, given the varied nature of the Government's ADP functions and processes.[30] The next step is to ask whether any distinction should be drawn between lease and purchase plans in the price evaluation for ADP contracts. One obvious factor to contend with is inflation. Supposedly, the 10% discount rate now used represents a real (vice nominal) rate of return, so there need be no additional concern for inflation.[31] The 1969 study which was the basis for OMB Circular A-94's 10% real rate of return, however, used an average inflation rate of 1.6% per year,[32] which does not even approach the levels of inflation experienced in the 20 years since the study. An alternative to the conceptual difficulties of using the opportunity cost method would be simply to discount for inflation, which would be an easier method of comparing pricing plans from an administrative perspective (i.e., just add the expected inflation percentage to the annual lease amount and then compare the total lease costs to the purchase price). Furthermore, if one believes in the Fisher effect, when expected inflation rises, interest rates rise as well,[33] which would provide at least an indirect connection to the desired concept of opportunity cost without the dubious theoretical underpinnings. To simplify the administrative cost of the current present value technique would be of benefit in itself, since this sort of economic analysis of pricing plans unnecessarily complicates the ADP acquisition process.[34] There would, of course, be the continual problem of finding an accurate prediction of inflation, so perhaps even this method of discounting is equally ill-advised, but it certainly has more support than the obsolete rate and questionable methodology now in use.

## CONCLUSION

It is ironic that the use of a 10% present value discount factor in ADP acquisitions has had the opposite effect of that intended by the decision makers who imposed the rate with an eye toward controlling public expenditures. In any event, the entire concept of discounting for imputed private opportunity cost has an ill-considered theoretical foundation. The Government's several regulations on present value discounting are full of contradictions and show a lack of consistency in approach, which reveals a more fundamental lack of understanding of the objectives of discounting. The net result has been both increased spending and unnecessary complexity in ADP and telecommunications contracts, with the latter factor providing fodder for bid protests.

One of the most pressing problems of public expenditure that has, until recently, been obscured by the narrow focus on present value discounting is the larger issue of funding the public debt. In this regard, Buchanan notes: "The best than can be done is to insure that, insofar as individuals try to estimate accurately the future benefits in comparison with future costs, as much information as possible concerning the extent of these future income and payment streams be provided. It becomes essential that some method of financing the debt service and amortization be adopted at the time of the initial decision. It is the height of folly to allow individuals to choose a bond issue to finance a long-term project with no corresponding means of paying the service charges."[35] In a very real sense, applying a present value analysis in the way that is currently required for most ADP and telecommunications contracts is to make this same sort of error, for to give preference to a lease rather than a purchase plan for a contract is to create the illusion that we need not pay today for the equipment we will use tomorrow; providing purchase funds should be the primary objective, and it the cost seems too large, then perhaps the money should not be spent at all, for to lease will only add to the cost of Government to society.

OMB recently alluded to this larger problem of public expenditure in criticizing agencies for disguising the true cost of Government projects by leasing instead of purchasing. Sound use of taxpayer funds requires simultaneous decision making on issues of spending and funding.[36] The answer to the often-heard comment that the Government must lease ADP because no purchase funds are available is not to lease and thereby hide (and compound) the true expense involved, but for elected representatives and appointed budget officials to face up to the hard choices that public expenditure involves when deciding whether to fund a project.

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# SPENDING INSTABILITY AND ACQUISITION COSTS

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## ABSTRACT

Past secretaries of defense have complained to the Congress that defense spending instability causes the Pentagon to waste many billions of dollars each year. In their view instability disrupts plans that are carefully developed each year to produce major weapons efficiently. Members of Congress have replied that such plans are often padded or flawed and therefore require the spending revisions by lawmakers which produce chronic instability.

Economic production theory offers several tools to evaluate these arguments. The study employs one of the tools to determine how the annual output of major weapons programs varied during the 1976-1987 period according to the degree of annual spending stability enjoyed by individual programs. Over 200 program years are analyzed.

The analysis shows that programs that received close to their planned funding in a given year -- relatively stable spending -- typically planned to produce weapons with high efficiency the following year. Programs that received much more or much less funding than they had planned for -- unstable spending -- tended to propose inefficient production goals for the following year.

Further analysis shows that individual weapons programs: (1) faithfully met their planned production goals nearly every time that actual spending matched planned spending; and (2) often produced all the units planned for even when legislative revisions caused actual spending to fall short of planned spending by as much as 10% to 20%.

The study compares historical DoD-wide weapons production levels -- levels that were achieved in a decade of major spending instabilities -- with estimates of levels that could have been realized if every individual program had been able to plan each new year's production by accurately anticipating how much funding it would and did get. The results suggest that normal, chronic spending instability has caused great waste for the Pentagon and the nation.

## INTRODUCTION

In 1989 Defense Secretary Frank Carlucci estimated that instabilities in defense spending cost U.S. taxpayers about $10 billion annually in lost efficiency. If the figure is correct, the government's inability to assure stable spending during the 1980s deprived the country of what amounts to all the new weapons and equipment that were actually produced in 1985 -- and then some. He also proposed a legislative remedy.[1]

Mr. Carlucci failed to define spending instability clearly, however. And he did not explain how his estimate was developed, which may be one reason why the estimate has not been accepted or even discussed widely in ensuing months.

The unsupported pricetag for an obscure spending problem has not moved the Congress to act.

This study defines one aspect of historical defense spending instability. Measurable differences in production efficiency for individual weapons programs are identified which appear to be directly related to it. The findings indicate that, through a simple process, spending instability ocurring in one year has led to production inefficiency in the following year.

## INSTABILITY: DEFINITION AND CATEGORIES

A discussion of all conditions under which defense spending can be viewed as stable or unstable probably warrants several book-length studies by itself.[2] The present analysis defines instability as a marked constant-dollar difference between the amount of procurement spending proposed for a major weapons program in the president's annual budget request to Congress (presented each year in January or February for the fiscal year beginning the following October) and the amount actually appropriated and spent after the Congress has reviewed and revised the request.

It is generally accepted that legislative revisions to individual weapons procurement spending requests, or yearly spending plans, have been the most frequent reason for significant constant-dollar (or real) differences that have arisen between the requested amounts and the figures actually spent by the programs.[3]

Real differences have also arisen when the Congress approved a nominal money request without revision but prices later accelerated or decelerated at a different rate than anticipated by planners. However, such differences have tended to be modest. They normally have not exceeded several percentage points.[4]

Thus, a difference of at least 8 percentage points between a program's requested TOA (Total Obligational Authority) for procurement and the TOA amount it actually receives, where both spending figures are measured in constant dollars, is significant for two reasons: First, it means the requested funding level for that year was not a very stable basis for organizing the actual production of weapons systems. Second, a gap of at least 8 percentage points generally means that the Congress disagreed with the DoD regarding the appropriate spending level for the procurement program in the year in question.[5]

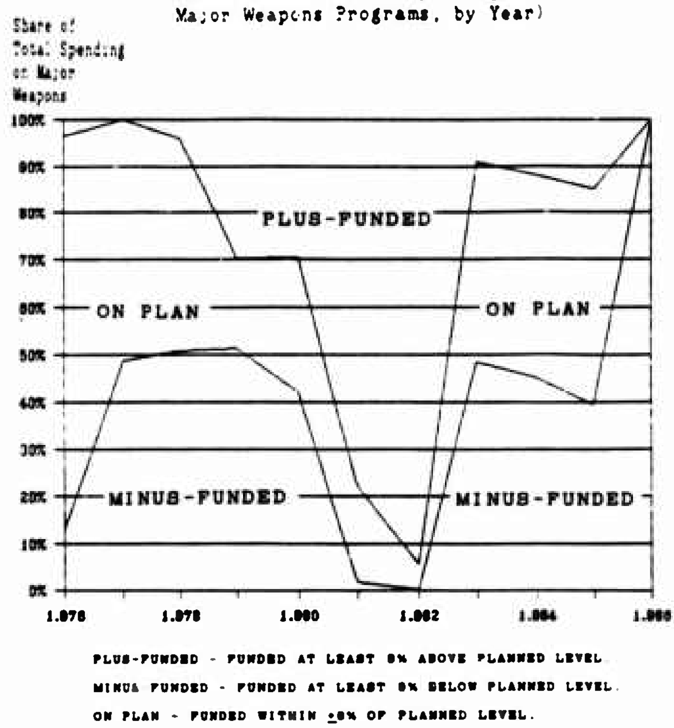
Charting Instability. By this standard weapons spending disagreements were strikingly common in the late 1970s and in the 1980s. For example, Figure 1 (bottom band) shows for total actual procurement spending on major weapons programs, 1976-1986, the proportion that was allocated each year to individual programs that received at least 8 percentage points less in funding than they requested.

Termed "Minus-Funded" cases, these programs represented 14% of the 1976 spending total, rising to around 50% of the totals in 1977-79, then dropping to near zero in 1982, and then rising to nearly 100% of all 1986 spending. Further analysis shows that actual (or congressionally approved) funding for the Minus-Funded cases averaged about 20% less than had been planned by the DoD and requested by the president.

Figure 1 (top band) also shows the funding that was actually allocated to "Plus-Funded" programs as a share of total annual major weapons procurement spending. This category includes weapons programs that received at least 8 percentage points more in funding than had been requested for the year. Plus-Funded

Figure 1

Program Funding Below, Near, and Above Planned Levels
(As Shares of Total Spending on
Major Weapons Programs, by Year)




programs represented less that half of the annual spending totals in every year except in 1981 and 1982.

Further analysis of the data over the entire period shows that the actual spending levels for Plus-Funded programs surpassed the amounts that had been requested by almost 50 percent on average.

Figure 1 (middle band) shows that funding for "On-Plan" programs -- those for which the Congress approved funds within plus-or-minus 8 percentage points of the amounts they requested for the year -- exceeded half of total spending in only two years, 1976 and 1977. Very little of total funding in 1982 and 1986 was spent to finance programs at near the levels that had been requested by the programs for those years.

Perpetual Motion. It should be noted that almost every specific aircraft, tank, missile, ship, and other major weapons program in production during the period was Minus-Funded, Plus-Funded, and On-Plan in various years. However, each appeared, by definition, in only one category in any given year.

To the casual observer, the movement over time of individual programs across categories, then back, and then across again, calls to mind the classic Brownian motion of molecules in perpetual flux.

Figure 1 suggests that annual spending instability, defined as real planned-to-actual procurement funding differences of at least 8 percentage points (plus or minus), was a normal condition among major weapons programs during the eleven years ending in 1986. Further analysis shows that only about 40% of all the funds appropriated for major weapons procurement during this period was allocated annually to individual programs at levels, relative to what they had requested, that qualified them as On-Plan for the year.

The analysis that follows is based on the foregoing distinctions among the categories of On-Plan cases, Minus-Funded cases, and Plus-Funded cases.[6]

## PLANNED OUTPUT AND ACTUAL OUTPUT

On-Plan cases comprise the historical set of program years that enjoyed relative spending stability. If spending stability affects weapons production differently than does spending instability, the differences should be discernable by comparing On-Plan cases with the other two categories of program years.

Hypothesis. In this section, the stability-category data are analyzed to determine how closely individual weapons programs have met their planned production goals when they received just the funds they requested and also when they didn't.

On this issue, the study hypothesis was that major weapons programs produce finished units in the numbers they have planned for when they receive just the funds they have requested.

Results. The degree of past concordance between planned and actual program output for On-Plan cases can be seen in Figure 2a. The figure plots measures of planned output and actual output for 64 On-Plan program years.

To standardize the data, each output measure in Figure 2a is expressed as a percentage change from the program's actual output level in the prior year. For example, concordance is complete if a program that planned a 10% increase in output subsequently produced 10% more units than it did the previous year. A planned 20% output reduction followed by an actual 20% reduction also demonstrates complete concordance.

Figure 2a shows a high degree of concordance for On-Plan cases as a set. The locus of plotted points on and near a 45-degree straight line drawn through the origin of the graph's axes signifies that On-Plan programs generally produced the numbers of units they said they would produce when they originally planned and requested funds for the fiscal year.

For comparison, Figures 2b and 2c show the loci of plotted points for 100 Minus-Funded program years and for 47 Plus-Funded program years, respectively. The former locus indicates low concordance because many points

Figure 2a

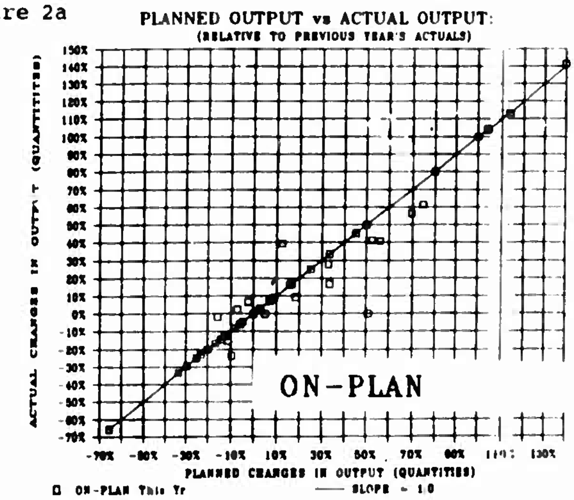



Figure 2b

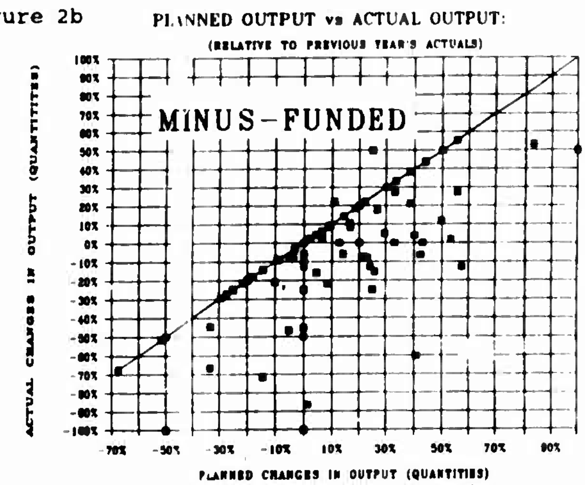
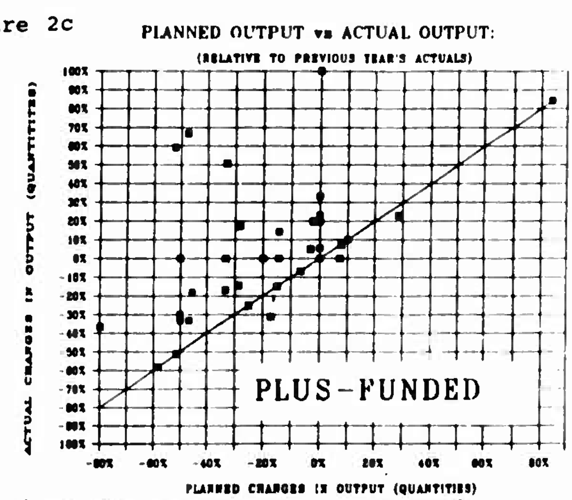



Figure 2c



production.

PRODUCTION FUNCTIONS AND EFFICIENCY

Cost analysts have successfully explored a vast array of production efficiency issues by evaluating the unit costs of manufactured equipment. Unit-cost analysis is drawn from the more general theory of economic production. Production theory also provides a simpler analytical tool known as production-function analysis to evaluate production efficiency.

As a coherent body of knowledge, production theory demonstrates that unit-cost analysis and production-function analysis yield identical answers to manufacturing problems when common assumptions and limits are used. Such a demonstration exceeds the scope of the present study.

Production-function analysis is used here because it deals directly with the relationship between the output of and major inputs to a production process. Funding is a major input to weapons production, as is short-term plant capacity, supply of skilled labor and critical parts, and so on.

Conceptually, the production function relates a range of output amounts to the amounts of specific input which bring them forth, as shown in Figure 3. The illustrative figure indicates that more efficient production occurs at some levels of the input's use than at other levels.

Hypothesis. When weapons production data are used to estimate the relationship between output and input amounts, not only can hypotheses be evaluated regarding the ranges where the input is used more and less efficiently: The production functions for two completely different classes of data can also be estimated and compared, thus allowing more complex hypotheses to be tested.

A hypothesis of this study was that the following-year planned production function for On-Plan cases tends to be higher (and more efficient) than the function for Minus-Funded cases.

Again, one reason is that while many Minus-Funded programs may need to "build in" compensating funds when they plan for production in the following year, On-Plan programs would not need to do the same. Hence, one should expect the latter to develop more efficient production plans than the former.

Results. Following-year data for planned output (finished units) and planned input (spending) are shown in Figures 4a, 4b, and 4c for the three stability categories.

To standardize the data, each following-year planned output level and input level is again expressed as a percentage change from the current year's actual level.

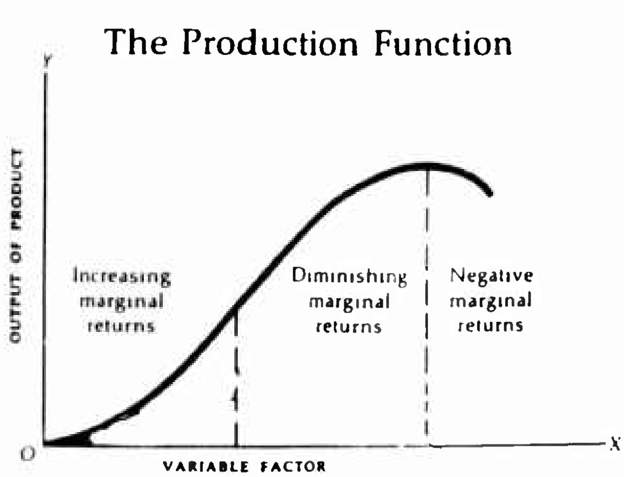
Figure 4a shows for each case that was On-Plan in the current year its planned spending for the following year and its corresponding planned output. The thin solid line indicates theoretically perfect concordance between percentage changes in planned spending and in planned production of finished units. High production efficiency relative to the current year's production is promised by plotted points that appear above the line; lower efficiency is associated with plotted points below the thin line.

Figure 4a also shows with a thicker solid line the estimated (least-squares fitted) production function planned by the On-Plan programs as a group.[7] The left-hand segment of the estimated function lies roughly parallel (with a slope of nearly 1.0) to, and about 5 percentage points above, the thin line of perfect concordance. The right-hand segment runs sharply upward (with a slope of nearly 2.0) from the thin line.[8]

In Figure 4a, the right-hand segment of the estimated production function confirms the general expectation in manufacturing activities that well-planned spending growth can yield efficiency through carefully expanded production. This segment indicates that the On-Plan programs that planned spending increases of 40 to 60 percent over the current year's level also proposed average output increases of 60 to 100 percent.

By comparison, Figure 4b shows that the locus of Minus-Funded programs lies close to the thin solid line of perfect concordance over its full length. The estimated production function for these cases (with a slope of nearly 1.0) runs almost parallel to the thin solid line and below it by roughly 5 percentage points.[9] This shows that Minus-Funded programs typically planned spending and output goals for the following year which promised somewhat less efficient production than they were actually attaining in the current year.

Figure 3



# THREE PRODUCTION FUNCTIONS:

Figure 4a

PLANNED OUTPUT vs PLANNED SPENDING:

(RELATIVE TO current-year ACTUALS)

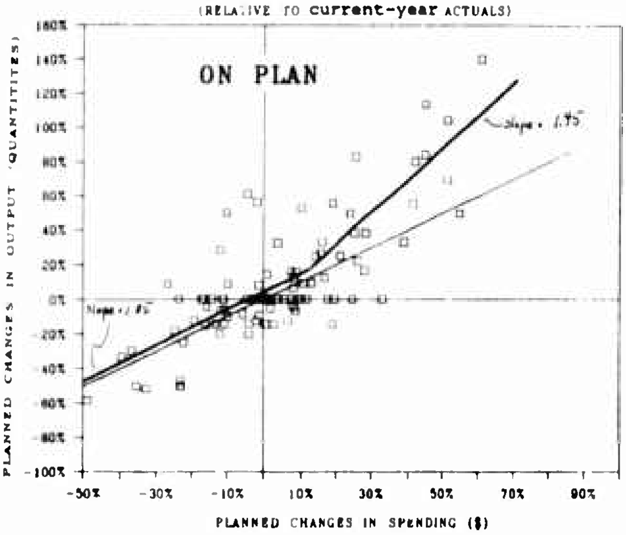



Figure 4b

PLANNED OUTPUT vs PLANNED SPENDING:

(RELATIVE TO current-year ACTUALS)

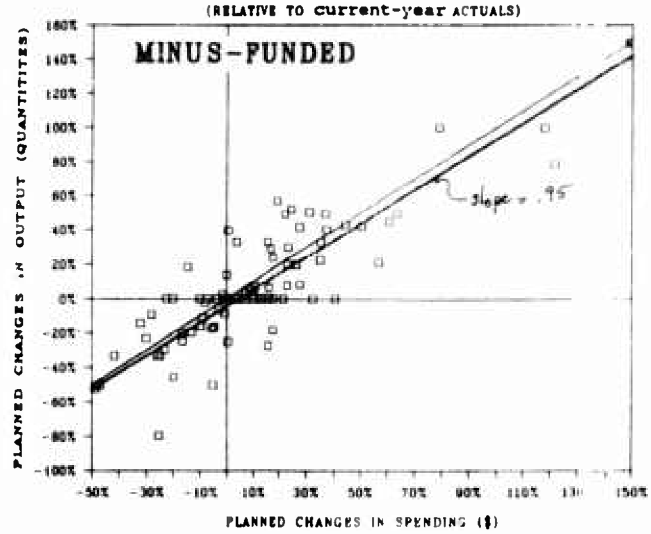
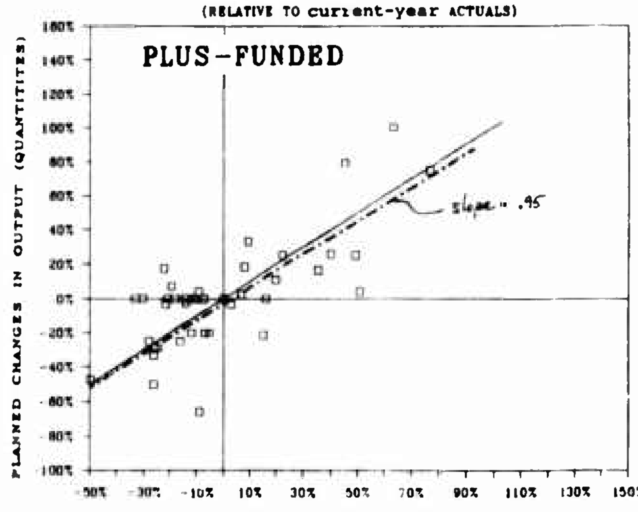



Figure 4c

PLANNED OUTPUT vs PLANNED SPENDING:

(RELATIVE TO current-year ACTUALS)




On average, moreover, the tendency to plan for slightly less efficient following-year production occurred among Minus-Funded programs regardless of whether major increases in spending, decreases, or little change from the current year's level were requested.

Figure 4c shows that the programs that were Plus-Funded in the current year tended to plan spending and output goals for the next year that were almost as lackluster as were the goals indicated by the production function for Minus-Funded programs in Figure 4b.

A Plus-Funded program approaches the next year without the need to "build in" funds to compensate for unplanned current-year cutbacks. Despite this, it is evident from the estimated function in Figure 4c that such programs did not, on average, make new annual plans to produce weapons with greater efficiency than the programs actually achieved in the current year -- not even when they requested major new spending increases.[10]

Bang vs. Buck. Comparison of Figures 4a and 4b indicates that currently On-Plan and Minus-Funded programs develop markedly different plans for the succeeding production year. The comparison does not disconfirm the study hypothesis that, for a given level of spending requested for the following year, a Minus-Funded program typically plans to produce fewer finished units than does an On-Plan program that is otherwise similar.

For example, comparison of Figures 4a and 4b shows that when both a Minus-Funded and an On-Plan program request a new 40% spending increase, the former normally proposes about a 35% increase in the number of units it will produce; the latter normally proposes about a 60% increase in number. Also, comparison using a broader output measure -- one that considers the relative quality of finished units -- may show the Minus-Funded program to be less efficient as well.[11]

## PLANNED AND ACTUAL PRODUCTION FUNCTIONS

A key finding of the analysis of stability-category production functions is that the degree of spending stability experienced in one year by a weapons production program does seem to directly influence whether the program's management will plan to produce weapons more or less efficiently during the next year. In particular, programs that currently enjoy a high degree of spending stability typically plan for fairly efficient production in the year to come.

Credible Plans. Production plans, of course, are not always the same thing as actual production. However, Figure 2a showed earlier that planned output, and therefore efficiency, goals are achieved faithfully when these plans are subsequently funded by the Congress without significant revisions. In such cases, the planned production function becomes the actual function.

This does suggest that fairly high production efficiency will actually be attained when a weapons program is able to develop and execute its plans year after year without needing to adjust repeatedly and abruptly because of significant revisions to its annual spending requests.

It is not clear from the analysis presented above that fairly efficient production also could be attained over time with unstable funding, i.e., through long successions of either unplanned yearly spending cutbacks or of unplanned increases -- or through a pattern of unplanned annual cutbacks and increases alternating with each other and with stable funding years.

Combined Tendencies. One reason for uncertainty on this matter is suggested by the earlier discussion of the data in Figure 2b on the tendency of Minus-Funded programs to absorb unplanned spending cutbacks without corresponding shortfalls relative to the numbers of units they planned to produce. That finding means that notable efficiencies have been attained in current-year production (relative to what had been planned) because of legislative revisions to program spending requests.

Whether the combination of current-year output efficiency achieved through an unplanned spending change plus following-year inefficiency in planned new production tends to yield a net gain or loss in efficiency for a typical weapons program is an issue that is being addressed by research that is currently nearing completion.

## ESTIMATED EFFICIENCY OF UNIVERSAL STABILITY

To provide general insight on net efficiency, the planned production function estimated in Figure 4a can be applied to historical data for the cases in all three stability categories.

Foresight. Recognizing that the planned production function for On-Plan programs approximates the actual function when a program's request is actually funded without revision, one may use the function to estimate the amount of output that each major program could have produced annually over the 1977-87 period.

That is, the above method provides an estimate of the annual production levels that could have resulted if universal spending stability had prevailed -- if each program had accurately anticipated, and therefore had specifically planned for, the spending that the program actually did receive every year throughout the period as reported in DoD documents.

All program years for all major weapons covered in the study were analyzed in this way. The resulting estimate of total cumulative weapons production under universal spending stability averaged over 10% more in the numbers of units produced than the total cumulative numbers of weapons that were actually produced for the military departments from 1977 to 1987. Again, this estimate assumes that:

1) Every program annually would have spent exactly what it is reported to have spent in the historical record; and

2) Every program would have remained On-Plan (avoided spending instability) by accurately planning for the funds it would and did receive in each new year.

## CONCLUDING REMARKS

The study's estimate of weapons output levels that might have been attained with universal stability, and the historical loss of efficiency the estimate implies, does not necessarily validate Defense Secretary Carlucci's cost figure for defense spending instabilities. Additional study is required to clarify the dynamics of, and responses by managers to instabilities in, the planning and spending allocation processes of the Defense Department as a whole.

Ongoing research by Dr. Rolf Clark and others promises to illuminate the dynamic structure of these basic processes.[12]

Equally, new research must bring more light to the process by which congressional revisions to program spending requests lead to more efficient or less efficient weapons production, model improvements, and support purchases in the year these revisions take effect and afterward.[13] Such research is underway at the Defense Systems Management College and other U.S. institutions. The results may eventually sharpen popular debate about the means and ends of public policies that affect defense spending instability and weapons production inefficiency.

## FOOTNOTES AND BIBLIOGRAPHY

[1] Frank C. Carlucci, Annual Report to the Congress: Fiscal Year 1990 (Washington, D.C.: U.S. Government Printing Office, 1989), pp. 8-9 and 85-89. The cost figure implies that: spending instabilities reduced the Defense Department's output, principally by reducing the annual production of new weapons; more stable spending would have raised output; and the total value of the added output would have been $10 billion annually. The accumulation of the lost ouput over ten years beginning in 1980, $100 billion worth of added weapons and services, would have exceeded the Department's record 1985 procurement effort by a large margin.

[2] See for example Booze Allen & Hamilton, Strageqies for Dealing with the Defense Budget (Fort Belvoir, Virginia: Defense Systems Management College, 1983) for over 300 pages of detailed discussion on a range of instability measures and issues. Also see Miguel Otegui's insightful review of historical instabilities by major appropriation categories and procurement accounts in a forthcoming article in the bimonthly Program Manager journal.

[3] Many of the legislative revisions to weapons program spending requests in FY 1981 and FY 1982 are exceptions to this rule because the incoming Reagan administration urged the Congress to revise (to raise in most cases) the requests for dozens of major programs which had already been presented by the outgoing Carter administration. See James W. Abellera and Roger P. Labrie, The FY 1982-86 Defense Program: Issues and Trends (Wash., D.C.: American Enterprise Institute, 1982), pp. 18-30.

[4] Thomas C. Cisewski, "A Reexamination of the Cost Estimating Problem in Major U.S. Weapons Systems, FY 1980-1987," George Washington University Technical Memorandum GWU/IMSE/Serial TM-55133/86, August 15, 1986, p. 12.

[5] The stated difference does not mean the Congress disagreed with all interested defense parties, however. Legislative revisions frequently reflect the successful efforts of factions in and around the Pentagon to overturn the defense secretary's spending judgements by appealing to the Congress to ignore specific program spending requests.

[6] The data sample used for the balance of the study excludes: "immature" major programs (those in serial production for less than four years); the B-1B, aircraft carrier, and MX missile programs because they operated under special constraints; and all other major programs for which two consecutive years of complete planned and actual production data were unavailable in public reports. The reports include the Defense Department's Annual Report to the Congress, fiscal years 1976 through 1989, and Acquisition Costs by Major Weapon System, fiscal years 1976 through 1989.

[7] The linear first-order regression equation underlying the estimated functions shown in Figures 4a through 4c actually consists of 16 independent variables, including special slope and intercept variables for the spending range from -20% to +20%. The graphical effects of these variables on the estimated functions are not shown in the figures to simplify discussion of comparative efficiencies. If shown, each estimated function would appear with a distinct linear segment, over the stated spending range, having a flatter slope (about 0.5) and a dependent-variable intercept of nearly zero at the x-intercept. The presented findings on comparative production efficiencies across stability categories are not altered by the graphical exclusion of these variables. Also, differences between the "On-Plan" estimated function's coefficients and the other two estimated functions' coefficients are significant at the 0.01 level. The R-squared value for the full regression equation is 0.74.

[8] The estimated slope coefficient for the right-hand segment (1.95) is significantly different from 1.0 at the 0.01 level.

[9] Note 7 applies.

[10] Ibid.

[11] If the Minus-Funded plan "builds in" additional funds mainly for model (quality) improvements of the type its On-Plan counterpart actually achieved in the current year, then the latter program's new planned output will automatically contain these improvements since quality changes do not generally disappear from one year to the next. Because the Minus-Funded program is simply catching up with its counterpart, the former's planned output will not exceed the latter's in quality per unit. Thus comparisons of planned production efficiency based on both output quality and numbers of new units will mirror the comparison based strictly on planned numbers of units.

[12] Investigations of some of these processes have been reviewed in Rolf Clark, "Defense Budget Instability and Weapon System Acquisition," Public Budgeting and Finance, vol. 7 (summer 1987).

[13] See Thomas L. McNaugher, New Weapons, Old Politics: America's Military Procurement Muddle (Washington, D.C.: Brookings Institution, 1989) for a detailed review of how legislative participation in acquisition decisions affects the efficiency and effectiveness of research and development activities long before weapons production begins.

# SYSTEMS ACQUISITION

# A GENERAL APPROACH TO DECISION MAKING UNDER UNCERTAINTY FOR SYSTEM ACQUISITION

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## ABSTRACT

*We are concerned here with the problem of selecting an optimal alternative in situations in which there exists some uncertainty in our knowledge of the state of the world. We show how the Dempster-Shafer belief structure provides a unifying framework for representing various types of uncertainties. We also show how the OWA aggregation operators provide a unifying framework for decision making under ignorance. In particular we see how these operators provide a formulation of a type epistemic probabilities associated with our degree of optimism.*

## INTRODUCTION

In many cases systems acquisition decisions are made in uncertain environments. In this situation one is concerned with the selection of an appropriate decision alternative, in the face of uncertainty with respect to the environment. The uncertainty manifests itself in that a different payoff is obtained for different states of nature. In this paper we provide a general formulation of this type of decision making. The Dempster-Shafer evidential structure [1-2] plays a crucial role in providing a unifying framework for representing the uncertainty. The Ordered Weighted Averaging (OWA) operators [3] play a central role in providing a unifying framework for aggregation. The introduction of these OWA operators provides a more general formulation than that used by Yager [4-5] in his previous work on decision making in the face of evidential knowledge.

We first discuss the classic problem of decision making under risk and ignorance [6]. In the environment of decision making under ignorance, we discuss the role of the decision maker's attitude in the selection of the procedure used to find the overall value associated with a particular alternative. In this environment we have a collection of possible outcomes, payoffs, but no probability associated with them. The value of this collection is determined by how optimistic or pessimistic the decision maker feels. We then show how the OWA operators provide a general framework for determining the value of a collection of outcomes. We next show how the Dempster-Shafer belief structure provides a suitable framework for representing, in a unified manner, the information a decision maker may have in regards to the state of nature. Finally we provide a methodology for selecting optimal alternatives in situations in which our knowledge about the uncertainty is contained in a Dempster-Shafer belief structure.

## DECISION MAKING UNDER UNCERTAINTY

A problem of considerable interest to decision makers can be captured by the following matrix:

$$\begin{array}{c|ccccc|}
 & S_1 & .. & S_j & .. & S_n \\
\hline
A_1 & C_{11} & .. & C_{1j} & .. & C_{1n} \\
. & . & & . & & . \\
A_i & C_{i1} & .. & C_{ij} & .. & C_{in} \\
. & . & & . & & . \\
A_q & C_{q1} & .. & C_{qj} & .. & C_{qn}
\end{array}$$

In the above each $A_i$ corresponds to a possible action (alternative) available to the decision maker. Each $S_j$ corresponds to a possible value of the variable called the *state of nature*. $C_{ij}$ corresponds to the payoff to be received by the decision maker if he selects action $A_i$ and the state of nature is $S_j$. The problem faced by the decision maker is to select the action which gives him the optimum payoff.

Since the payoff to the decision maker depends upon the state of nature his procedure for selecting the best alternative depends upon the type of knowledge he has about the state of nature.

In the classic literature dealing with this problem [6], three different decision making environments have been identified:

(1). Decision making under certainty
(2). Decision making under risk
(3). Decision making under ignorance

In the first case one assumes that the decision maker knows exactly

what is the state of nature is, for example $S_a$. In this case the course of action is straightforward. He selects the alternative that has the maximum payoff for this course of action.
Example: Consider the following payoff matrix

| | $S_1$ | $S_2$ | $S_3$ | $S_4$ | $S_5$ |
|---|---|---|---|---|---|
| $A_1$ | 7 | 5 | 12 | 13 | 6 |
| $A_2$ | 12 | 10 | 5 | 11 | 2 |
| $A_3$ | 9 | 13 | 3 | 10 | 9 |
| $A_4$ | 6 | 9 | 11 | 15 | 4 |

In this example if we know that the state of nature is $S_3$, then the action is to select is $A_1$.

In general in this environment we select the alternative $A^*$ such that

$$C^* = \text{Max}_i\, C_{ia}.$$

In the second environment, decision making under risk, it is assumed that we have a probability distribution over the states of nature. In this case we know for each $S_j$, $P_j$ the probability that $S_j$ is the state of nature. The standard procedure in this case is to use expected values:

1.For each alternative $A_i$ we calculate

$$C_i = \sum_j C_{ij} * P_j,$$

the expected payoff for alternative $A_i$.

2. Select as the optimal alternative, $A^*$, the one which has the largest expected payoff

$$C^* = \text{Max}_i\, C_i$$

Example: If $P_1 = .3$, $P_2 = .1$, $P_3 = .2$, $P_4 = .1$ and $P_5 = .3$ then using the payoff matrix of the previous example we get:

$$C_1 = (.3) * 7 + (.1)5 + (.2)(12) + (.1)13 + (.3)(6) = 8.1$$

and $C_2 = 7.6$, $C_3 = 8.3$ and $C_4 = 7.6$.
Thus the optimum choice under this probability distribution is $A_3$.

It should be noted that decision making under uncertainty can be seen as a special case of decision making under risk. In particular, if we know that $S_a$ is the state of nature, then we can consider $P_a=1$.

In the third environment, decision making under ignorance, we assume no knowledge about the state of nature other than that it is an element in some set

$$S = \{S_1, S_2, \dots S_n\}$$

The methodology used in the selection of the optimal alternative in this environment requires the assumption of a particular decision attitude by the decision maker. Among the decision attitudes discussed in the literature [6] are the following:
(1). Pessimistic attitude - Using this strategy the decision maker selects for each alternative the worst possible outcome and then selects the alternative that has the best worst. This strategy is sometimes called the maximin strategy.
(2). Optimistic attitude - Under this strategy, the decision maker selects for each alternative the best possible outcome and then selects the alternative that has the best best. This strategy is called the maximax strategy.
(3). Hurwicz Approach - In this approach the decision maker selects a value $\alpha \in [0,1]$. Then for each alternative he takes a weighted average of the optimistic and pessimistic value

$$H = \alpha * \text{Pess} + (1 - \alpha) * \text{Opt}.$$

He then chooses the alternative which has the highest H value.
(4). Normative Approach - In this approach for each alternative the decision maker sums the payoffs across all possible outcomes and then selects the alternative with the highest total.

In the case of the decision making under ignorance one can see that the general formulation of the selection process is as follows:

(1). For each $A_i$ calculate

$$V_i = F(C_{i1}, C_{i2}, \dots C_{in}),$$

in the above F is some aggregation function whose form depends upon the decision makers assumed attitude.

(2). Select the alternative $A^*$ such that

$$V^* = \text{Max}_i[V_i]$$

We note that for each of the four previously discussed decision attitudes F is as follows:

(1). Pessimistic Strategy

$$F(C_{i1}, C_{i2}, \dots C_{in}) = \text{Min}_j\, C_{ij}$$

(2). Optimistic Strategy

$$F(C_{i1}, C_{i2}, \dots C_{in}) = \text{Max}_j\, C_{ij}$$

(3). Hurwiez Strategy

$$F(C_{i1}, C_{i2}, \dots C_{in}) = \alpha * \text{Max}_j\, C_{ij} + (1 - \alpha)\, \text{Min}_j\, C_{ij}$$

(4). Normative Strategy

$$F(C_{i1}, \dots C_{in}) = \sum_j C_{ij}$$

The following example illustrates these four strategies.

Example: Using the previous payoff matrix the valuations under each of the attitudes are captured in the following table:

| | Pessimistic | Optimistic | $\alpha = .5$ | Normative |
|---|---|---|---|---|
| $A_1$ | 5@ | 13@ | 9 | 43 |
| $A_2$ | 2 | 12 | 7 | 40 |
| $A_3$ | 3 | 13@ | 8 | 44 |
| $A_4$ | 4 | 15 | 9.5@ | 45@ |

Under each column the @ mark indicates the optimal alternative for that attitude.

## A GENERAL APPROACH TO ALTERNATIVE SELECTION UNDER IGNORANCE

In this section we shall suggest a general formulation to the optimal alternative selection problem under ignorance. This approach will be based upon the ordered weighted averaging (OWA) operators introduced by Yager [3]. We shall see that this general approach allows the four previously discussed methods as special cases.

In suggesting a general approach to alternative selection one should be concerned that it satisfies certain properties which one can consider as rational. A first desiteria is that of pareto optimality. This condition requires that given two alternatives A and B, where A has at least as high a payoff as B for each state of nature, then B should **not** be more preferred than A. A second condition is that it should treat the states of nature uniformily. Another desirable, though not necessary, requirement, is that the aggregation across the states of nature be an averaging like operation in the sense that if for a given alternative all the states of nature have the same payoff, a, then the overall value of that alternative should be a. In [3] Yager introduced a new type of aggregation operator called OWA operators. In [7] he suggested some extensions of these operators. O'Hagan [8] has investigated their use in expert systems.

Def: An ordered weighted averaging operator (OWA) of dimension n is a function

$$F : R^n \to R$$

that has associated with it a weighting vector W,

$$W = \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ w_n \end{bmatrix}$$

such that

(1). $w_i \in [0,1]$

(2). $\sum_i w_i = 1$

and for any set of values $a_1, \dots a_n$

$$F(a_1, \dots a_n) = \sum_i (w_i * b_i)$$

where $b_i$ is the $i^{th}$ largest element in the collection $a_1, a_2, \dots a_n$.

Example: If

$$W = \begin{bmatrix} .3 \\ .4 \\ .2 \\ .1 \end{bmatrix}$$

then

$F(10, 0, 20, 30) = (.3) * 30 + (.4) * 20 + (.2) * 10 + (0) * 1 = 19$

It should be noted that the weights in the OWA operator are associated with a position in the ordered arguments rather then a particular argument.

It is our suggestion that the OWA operators provide a family of operators, parametized by W, which can be used to help in the selection of optimal alternatives in the face of ignorance. In particular we can use these operators to provide the aggregated value for each alternative. We can calculate

$V_i = F(C_{i1}, C_{i2}, \dots C_{in})$

where F is an OWA aggregation operator. We then select the alternative that has the highest V value.

First we note that for any W the OWA aggregation operation satisfies the condition of pareto optimality. In particular if

$$a_j \geq d_j \quad \text{for all } j = 1, \dots n \text{ then}$$
$$F(a_1, \dots\dots, a_n) \geq F(d_1, \dots\dots, d_n)$$

Next we shall show that the four methods previously discussed are special cases of OWA operators.

(1). **Pessimistic Attitude**

If we select $W_*$ where

$$W_* = \begin{bmatrix} 0 \\ 0 \\ . \\ . \\ 1 \end{bmatrix}$$

then $F_*(a_1, \dots a_n) = \text{Min}_j[a_j]$, which is the aggregation rule used in the pessimistic strategy.

(2). **Optimistic Attitude**

If we select $W^*$ where

$$W^* = \begin{bmatrix} 1 \\ 0 \\ . \\ . \\ 0 \end{bmatrix}$$

then $F^*(a_1, \dots a_n) = \text{Max}_j[a_j]$, which is what is used in the optimistic strategy.

(3). **Hurwicz Strategy**

If we select

$$W_H = \begin{bmatrix} \alpha \\ 0 \\ . \\ 0 \\ 1-\alpha \end{bmatrix}$$

then

$F_H(a_1, \dots a_n) = \alpha * \text{Max}[a_j] + (1 - \alpha) * \text{Min}[a_j]$

This is exactly the formulation used in the Hurwicz strategy.

(4). **Normative approach**

If we select

$$W_N = \begin{bmatrix} 1/n \\ 1/n \\ . \\ 1/n \end{bmatrix}$$

then we get

$F_N(a_1, \dots a_n) = 1/n \sum_i a_i$

This function is essentially the normative strategy.

We should note that the pessimistic and optimistic strategies provide limiting classes of OWA operators. It can be easily shown [3] that for any OWA operator F and any set of arguments $(a_1, \dots a_n)$ that

$$F_*(a_1, \dots a_n) \leq F(a_1, \dots a_n) \leq F^*(a_1, \dots a_n).$$

In [7] Yager suggests a semantics that can be associated with the OWA aggregation procedure in this framework of decision making under ignorance. This semantics will provide a unifying interpretation of this operation. Yager suggests that we can view the OWA weights as a kind of probability distribution. In particular we can view $w_i$ as the **probability that the $i^{th}$ best thing** will happen. We recall that the weights have the properties of a probability distribution in that each $w_i$ lies in the unit interval and the sum of the $w_i$'s is one. From this interpretation we see that the aggregation associated with each particular alternative can be seen as the expected value under this probability distribution. If $C_{i1}$, $C_{i2}$, ... $C_{in}$ are payoffs corresponding to each of the states of nature under the selection of alternative $A_i$ then $b_1$, ... $b_j$ are the ordered set of these payoffs. Then if $w_1$, ... $w_n$ are the OWA weights interpreted as probabilities of the $j^{th}$ best thing happening under any selection of alternative we see that,

$$V = \sum_j w_j * b_j$$

is the expected payoff in this case. Thus the OWA aggregation provides a kind of expected value similar to that used in decision making under risk. The difference between the two situations is that in later, decision making under risk, we have assigned a probability $p_i$ to each particular state of nature $S_i$. In decision making under ignorance the probabilities, the weights, are assigned not to a particular state of nature, but to the preference ordered position of the payoff. Using this interpretation we can see that the pessimistic strategy is effectively a situation in which a probability of one is assigned to the worst thing happening given any selection of alternative. In the optimistic approach we are assuming a probability of one is assigned to the possibility of the best thing happening. In the normative case we are assuming equal probability for each of the preference positions. The Hurwicz strategy is effectively assigns a probability $\alpha$ that the best thing will happen and $1 - \alpha$ probability that the worst thing will happen.

In [3] Yager introduced a number of measures associated with the weights of an OWA operator, we briefly describe these.

Assume W is a set of weights then the measure of **Optimism** associated with these weights is defined as

$$Opt(W) = \sum_{j=1}^{n} w_j * h_n(j)$$

where $h_n(j) = (n - j) / (n - 1)$.

We note that $Opt(W^*) = 1$, $Opt(W_*) = 0$, $Opt(W_n) = .5$ and $Opt(W_H) = \alpha$

A second measure associated with these weights is a measure of entropy or dispersion

$$DISP(W) = - \sum_j w_j \ln(w_j).$$

We should note that the larger the Disp(W) the more of the payoffs play a role in the determination of F. O'Hagan [8] has studied these measures in considerable detail.

A question that naturally arises, is, how does a decision maker obtain the weights he is going to use in solving a particular problem? At the fundamental level, the answer is that he subjectively decides, just as he does in deciding to be pessimistic or optimistic or normative. The most straight forward way of obtaining the weights is for the decision maker to directly select the values of the weights. In doing this, if he chooses to allocate, the allotted total of one, to weights near the top of the vector, he can be seen as being optimistic. If he allocates the weights to elements near the bottom he is being pessimistic.

An alternative method of selecting the weights has been suggested by O'Hagan [8]. With this approach the decision maker subjectively decides upon his coefficient of optimism $\beta$. He then inputs this value into a mathematical programming problem which is used to obtain the weights that have an appropriate degree of optimism while maximizing the dispersion.

The mathematical programming problem is

**Maximize** : $- \sum_j w_j \ln(w_j)$ (entropy)

**Subject to:**

$$\sum_j (h_n(j) * w_j = \beta$$

$$\sum_j w_j = 1$$

$$w_j \geq 0 \quad \text{for all } j = 1, \ldots n$$

This approach is closely related to the maximum entropy method used in probability theory.

One benefit of this approach is that we can consistantly provide for weights corresponding to a given $\beta$ for various different cardinalities of OWA operators.

## A GENERAL FRAMEWORK FOR REPRESENTING UNCERTAINTY

In a previous section we suggested that there was two distinct situations with respect to the knowledge about the state of nature. These two were risk and ignorance. Actually we also discussed certainty but we suggested that this was a special case of risk, one in which the probability of some outcome is one. It actually can also be seen as a special case of ignorance where the set S consists simple of one element.

In this section we introduce a more general framework for the representation of uncertainty. This scheme is called the Dempster-Shafer theory of evidence [1-2]. We shall show that the two cases, risk and ignorance, are special cases of this more general formulation. In cases of this more general formulation. In addition to being able to capture these classic formulations of our knowledge about uncertain environments these new structure allows us to easily represent various other forms of information a decision maker may have about the state of nature. The Dempster-Shafer framework has proved to be an important and useful tool in the development of expert systems.

A belief structure m on the set Y consists of a collection of non-empty subsets $B_i$ of Y and an associated set of weights $m(B_i)$ such that:

$$1).\ m(B_i) > 0 \quad \text{and} \quad 2).\ \sum_j m(B_j) = 1$$

The subsets $B_i$ are called the focal elements of the belief structure.

A very applying feature of this belief structure is that it can be used to represent in a unified manner various types of uncertainty we previously discussed. In the following we shall let Y be the set of possible states of nature.

If the belief structure consists of n focal elements such that $B_i = \{y_i\}$, each focal element is a singleton, then we essentially have the decision making under risk environment where $m(B_i) = P_i$ $=\text{Prob}\ \{y_i\}$.

If our belief structure has only one focal element B, where $m(B) = 1$, then we essentially have the decision making under ignorance environment.

In addition to these two basic formulations of our knowledge the Dempster-Shafer formulation allows us to capture other more sophisticated forms of knowledge.

If our knowledge of the state of nature is such that we know that there is a probability p that the state of nature lies in the set A and 1 - p that it lies in not A then we can represent this by a belief structure with two focal elements as follows:

$B_1 = A \qquad m(B_1) = p$

$B_2 = \text{not } A \qquad m(B_2) = 1 - p$

A closely related belief structure is one in which

$B_1 = A \qquad m(B_1) = p$

$B_2 = Y \qquad m(B_2) = 1 - p.$

With this belief structure we are essentially saying that the probability of A is at least p.

The essential point of this section is that the use of the Dempster-Shafer belief structure provides a unifying method for representing our knowledge about the state of nature in decision making problems.

## DECISION MAKING WITH BELIEF STRUCTURES

The Dempster-Shafer belief structures have proven to be a very useful representation scheme for expert and other knowledge based systems. In many cases the knowledge provided by these types of expert systems is in the form of a belief structure. A problem that is of considerable interest is that of selecting an appropriate course of action, alternative, in situations in which our knowledge about the state of nature is in the form of a belief structure. In this section we shall bring all the pieces together to provide a unified approach to decision making under uncertainty. This work provides a generalization of the ideas discussed by Yager in [4-5].

Assume we have a decision problem in which we have a collection of q alternatives from among which we must choose one. We denote the set of alternatives as $A = \{A_1, \ldots A_q\}$.

In addition we assume that the payoff, to the decision maker, depends upon the value of some variable, which we call the state of nature. We assume the value of this variable is some element in the set S, where $S = \{S_1, \ldots S_n\}$

We assume that $C_{ij}$ is the payoff to the decision maker if he selects alternative $A_i$ and the state of nature is $S_j$. In addition we assume our knowledge of the state of nature is captured in terms of a belief structure m on S. The focal elements of m are $B_1, \ldots B_r$ and associated with each of these is a probability mass value $m(B_j)$. The problem of concern is to select the alternative which maximizes the payoff to the decision maker.

The procedure we suggest using for the determination of the best alternative is an extension of the previously described methods which combines the schemes used for both decision making under risk and ignorance. We shall call this decision making under uncertainty. In a manner similar to decision making under risk we obtain a *generalized expected value*, $C_i$, for each alternative $A_i$. However, in obtaining this expected value we use the weights associated with the focal elements as the probabilities. The second step is to select the alternative which has the largest generalized expected value.

The generalized expected value, $C_i$, for a given alternative, $A_i$, is obtained using the evidential knowledge. The knowledge contained in the belief structure tells us that $m(B_k)$ is the probability that $B_k$ will be the set that will determine the state of nature. In particular

$$C_i = \sum_{k=1}^{r} V(A_i, B_k) * m(B_k)$$

In the above $V(A_i, B_k)$, which we shall denote as $V_{ik}$, is the payoff we get when we select alternative $A_i$ and the state of nature lies in $B_k$. Thus we see that $C_i$ is essentially the expected value of the payoffs under $A_i$.

The determination of the value $V_{ik}$ can be seen as equivalent to the problem of decision making under ignorance. In particular for a given $A_i$ and the knowledge that the state of nature lies in $B_k$ we end up with a collection of possible payoffs. We shall let $M_{ik}$ denote the collection (bag) of payoffs that can occur under $B_k$. In this case each element $S_j$ in $B_k$ contributes one element to $M_{ik}$, its payoff under $S_j$, hence

$$M_{ik} = \langle C_{ij} \mid S_j \in B_k \rangle.$$

In order to determine the value of $V_{ik}$ from $M_{ik}$ we use the procedure developed for decision making under ignorance. First we obtain from the [illegible]cision making his measure of optimism $\alpha$. This measure of optimusm is then used to solve the mathematical program problem described earlier to obtain the weights for the OWA vectors. Actually we must solve this problem for each different cardinality of $M_{ik}$.

Using these weights we can find $V_{ik} = F(M_{ik})$ where F is an OWA operatior whose weights are determined above for a degree of optimism $\alpha$ and cardinality of $M_{ik}$.

The following summarizes the operations, assuming we have obtained the payoff matrix, the belief function m about the state of nature and the decision makers degree of optimism, $\alpha$.

(1). Solve for each different cardinality of focal elements the mathematical programming problem with the degree of optimism $\alpha$. This gives us a collection of weights to be used in OWA aggregation.

(2). For each alternative i do the following:

a) For each focal element, $B_k$, calculate $M_{ik}$, the collection of payoffs corresponding to that focal element.

b). For each $M_{ik}$ calculate, using the appropriate OWA operator, $V_{ik} = F(M_{ik})$.

c). Calculate $C_i = \sum_k V_{ik} * m(B_k)$

3). Select the alternative which has its highest $C_i$ as the optimal alternative.

The following example illustrates the procedure.

Example: Assume our payoff matrix is the one used earlier. In addition assume that our knowledge of the state of nature consists of the following belief structure, m:

| Focal element | Weights |
|---|---|
| $B_1 = \{S_1,S_3,S_4\}$ | .6 |
| $B_2 = \{S_2,S_5\}$ | 3 |
| $B_3 = \{S_1,S_2,S_3,S_4,S_5\}$ | .1 |

We shall assume that the decision maker has a degree of optimism of .75. Solving the appropriate mathematical programming problems we obtain the weights associated with the OWA operators for various numbers of arguments under the optimism value of .75: [8]

| # of arguments | $w_1$ | $w_2$ | $w_3$ | $w_4$ | $w_5$ |
|---|---|---|---|---|---|
| 2 | .75 | .25 | | | |
| 3 | .62 | .27 | .11 | | |
| 4 | .52 | .27 | .14 | .07 | |
| 5 | .46 | .26 | .15 | .08 | .05 |

We next calculate the bags $M_{ik}$. We recall $M_{ik}$ is the collection of payoffs that are possible if we select alternative $A_i$ and the focal element $B_k$ occurs:

$M_{11} = \langle 7, 12, 6\rangle$, $M_{12} = \langle 5, 13\rangle$, $M_{13} = \langle 7, 5, 12, 3, 6\rangle$,
$M_{21} = \langle 12, 5, 2\rangle$, $M_{22} = \langle 10, 11\rangle$, $M_{23} = \langle 12, 10, 5, 11, 2\rangle$
$M_{31} = \langle 9, 3, 9\rangle$, $M_{32} = \langle 13, 10\rangle$, $M_{33} = \langle 9, 13, 3, 10, 9\rangle$
$M_{41} = \langle 6, 11, 4\rangle$, $M_{42} = \langle 9, 15\rangle$, $M_{43} = \langle 6, 9, 11, 15, 4\rangle$.

Next we calculate $V_{ik}$, using the ordered weighting average operation: We recall that $V_{ik} = F(M_{ik})$. Hence
$V_{11} = (.62) * 12 + (.27) * 7 + (.11) * 6 = 9.99$.
Similarly we calculate
$V_{12} = 11$, $V_{13} = 10.88$, $V_{21} = 9.01$, $V_{22} = 10.75$, $V_{23} = .10.38$
$V_{31} = 8.34$, $V_{32} = 12.25$, $V_{33} = 10.8$, $V_{41} = 8.88$ , $V_{42} = 13.5$
and $V_{43} = 11.79$.

Finally we use these values to obtain the generalized expected value for each alternative:

$$C_i = V_{i1}\, m(B_1) + V_{i2} * m(B_2) + V_{i3} * m(B_3)$$
$$C_i = .6 * V_{i1} + .3 * V_{i2} + .1\, V_{i3}$$

Therefore $C_1 = 10.382$, $C_2 = 9.67$, $C_3 = 9.759$ and $C_4 = 10.557$.
Given the above information the the optimal choice is alternative $A_4$.

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# A-109 -- FOR BETTER OR FOR WORSE?

## A RE-EXAMINATION OF SOME TOP-LEVEL POLICIES ON ACQUISITION OF MAJOR WEAPON SYSTEMS

by

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### ABSTRACT

Office of Management and Budget Circular A-109 is the top-level policy document for major systems acquisition in the entire executive branch. It was primarily aimed at establishing tighter control over systems acquisition by focusing on the front end of the process. The philosophy embodied by A-109 has now been in place for almost two decades (the document itself is over 13 years old), spanning four administrations. Thus, there has been adequate time for the policy to take root at the operational level and for enough unambiguous, measurable data to have accumulated for an objective assessment of its effectiveness.

This paper evaluates the impact of the A-109 philosophy on the defense acquisition process in terms of its effect on (1) cost, (2) cost growth, (3) length of the acquisition cycle, and (4) merit of systems that enter the acquisition pipeline.

### INTRODUCTION

In the late 1960's there was concern that weapon systems were moving too quickly from paper studies to full scale development (FSD), without adequate maturation and testing at the subsystem level. As a result of that concern, the Demonstration/Validation phase was formalized in 1971 with the publication of the first version of DODD 5000.1. In the early 1970's there was further concern that the Services were meeting their requirements by simply building upgraded versions of existing systems, without giving adequate consideration to new and innovative concepts from industry which might provide more effective solutions. Consequently, the Concept Exploration phase was formalized in 1976 by the publication of A-109 as the top-level document for acquisition policy in the entire executive branch. A-109, however, added another dimension as well. It added the requirement that the Secretary of Defense be involved at the initiation of each of these phases (viz., at Milestones 0 and I) and that Congress be notified at the beginning of Concept Exploration. The philosophy prescribing early involvement of OSD and Congress was driven by the fact that most of a system's life cycle cost is locked in by decisions during the very early phases when the actual expenditures themselves are relatively very small.

There is an unimpeachable logic to A-109, but how well has it really worked in the defense acquisition environment?

### COST GROWTH

Most modern weapon systems cost much more to develop and produce than the weapons they are replacing. Three key issues frequently arise in conjunction with this increased cost. One concerns performance. Not only do the new weapons cost more, but they also provide significantly improved performance and capability, e.g., more destructive power, much better accuracy, etc. A discussion as to whether the improved performance usually justifies the additional cost is outside the scope of this paper. The second issue concerns the management process. What fraction of the cost could be saved by a more effective and efficient management process? This question is addressed elsewhere in the paper.

The third issue, and the focus of this section, concerns cost growth, namely, the fact that we usually end up paying much more for the weapon systems than we initially expected. In plain language, we incur cost overruns. Cost growth may be defined as the ratio of the actual cost of the fielded system to the estimated cost at the time the system entered the acquisition pipeline. The actual cost usually does not become known with complete certainty until after the system has been in production for several years.

To keep a program experiencing cost overruns intact, funds must be taken away from other programs. This sets off a chain reaction wherein the schedules of the other programs are stretched in order to accommodate their reduced funding profiles, and these delays in turn give rise to changes in threat projections, requirements, and performance -- all of which in turn generate additional cost overruns for the affected systems.

Why do we often have cost overruns? In the most general sense, because we have great difficulty estimating the true cost of future new developments. Obviously, the more distant in time the delivery of a final product is, the more difficult it is to accurately predict its ultimate cost. This is superimposed upon an acquisition process wherein a system's survival probability is enhanced if the full magnitude of its higher ultimate cost does not surface in the early phases of the cycle. Former DoD Comptroller John R. Quetch used to refer to the tendency to underestimate cost as the "conspiracy of optimism." It arises from the fact that, having never built the system before, we cannot fully anticipate all the difficulties that may come into play in the course of developing it.

How severe have the cost overruns been since 1970, i.e., since DOD major systems have been operating in an environment of a formalized front-end acquisition process in accordance with the basic philosophy of A-109? And how do these overruns compare with those experienced in earlier decades? Addressing these questions in a paper in the fall 1985 issue of *The National Estimator*,
F. Biery showed that the mean cost overrun for a data sample of 22 major systems started in the 1970s was 59%, compared with a mean value of 45% (for a sample of 13 major systems) in the 1960s, and 86% (for a sample of 15 major systems) in the 1950s. In other words, as far as cost overruns are concerned, at first glance Biery's data seem to suggest that we are doing much better than we did in the 1950s but not as well as in the 1960s.

A closer examination of the results, however, reveals a major difficulty in making such a comparison. The difficulty lies in the forecasting horizon associated with the data, namely, the length of time between the initial estimate (at the point where the system entered the acquisition pipeline), and the point in the cycle when the actual total costs became known with complete certainty. The post 1970 cost overruns have an average forecasting horizon of 8.2 years associated with them, whereas the mean forecasting horizons associated with results of the 1950s and 1960s are 3.8 and 3.6 years, respectively. This would indicate that the initial cost estimates associated with the reported overruns of the 1950s and 1960s were probably made at points well into Full Scale Development (i.e., at points in the acquisition cycle where we usually have much greater visibility into the ultimate cost of the system) and not when the systems entered the acquisition pipeline. Consequently, the cost overruns of both the 1950s and 1960s probably appear much lower than they would have been under forecasting horizons comparable to those associated with the post-1970 results. This is not surprising in light of all the additional management machinery that has been instituted since 1970 -- e.g., formalized Concept Exploration and Dem/Val phases, an independent Cost Analysis Improvement Group (CAIG), increased independent testing, reduced concurrency, etc.

## LENGTH OF THE ACQUISITION CYCLE AND ASSOCIATED COST

The time span from the point of launching the development of a new system to the point where it is put in the hands of an appropriate combat unit, thereby providing an initial operational capability, is usually referred to as the length of the acquisition cycle. How long is the current acquisition cycle for major weapon systems? According to the 1986 Packard Commission report it is about 15 years. A more precise figure is given in a 1980 General Accounting Office report showing the current average acquisition cycle for major systems to be 15.6 years. Of this time, the system spends 4.8 years in concept exploration, 4.3 years in demonstration/validation, and 6.5 years in full-scale development and early production. Beyond this point, the system usually spends additional years in full-scale production. How does that compare with the length of the cycle prior to 1970? A 1983 Air Force report, "Affordability Acquisition Approach," shows that before 1970, a major weapons system spent on the average (1) only about 2.1 years in pre-FSD phases (versus 9.1 now) and (2) from FSD to IOC, approximately one year less than currently. A similar conclusion was reached by the late Congressman R. M. Ichord, a leading defense acquisition expert, who pointed out in a 1980 paper that the U.S. acquisition cycle had about doubled in the 1970-1980 decade alone.

Why should we be concerned about the length of the acquisition cycle? Ichord notes in his 1980 paper that "Of all the serious problems besetting the military, none is more profound or far-reaching than the dangerous amount of time it takes the U.S. to move a new weapon system from concept to combat readiness." He goes on to say that the acquisition cycle is now so long that it is "diminishing U.S. technological superiority, an advantage we have traditionally used to counterbalance Soviet numerical superiority in both weapons and manpower. Too often, the technological superiority of which we speak is only in the laboratory. Clearly, our technological advantages are of little benefit unless they are put to practical use in a relatively short time." Furthermore, the 1986 Packard Commission report considers our current "unreasonably long acquisition cycle" as the "central problem from which most other acquisition problems stem: It leads to obsolete technology in our fielded equipment. We forfeit our five year technological lead by the time it takes us to get our technology from the laboratory into the field."

Is it realistic to aim for a much shorter acquisition cycle when dealing with such large and complex systems? To answer that question we need to take a look at the commercial sector. How does the current length of the acquisition cycle for major weapon systems compare with the length of the cycle associated with successful programs of comparable magnitude and complexity in the commercial sector? A 1985 Defense Science Board study looked at a sample of such programs -- the IBM 360 computer, the Boeing 767 transport, the AT&T telephone switch, and the Hughes Communications Satellite--and found that each took only half as long as comparable DOD systems to develop.

This brings us to the question of scale. The annual DOD budget for materiel is much larger than the total annual sales of IBM, Boeing, AT&T and Hughes combined. Is a significantly shorter acquisition cycle achievable in a bureaucracy of such enormous size? To answer that question, the Packard Commission "examined several DOD programs that were developed under special streamlined procedures -- the Polaris Missile, the Minuteman Missile, the Air-Launched Cruise Missile (ALCM), and several highly classified projects" -- and found that "in these programs DOD achieved the accelerated schedules of the successful commercial programs," i.e., roughly 8 years instead of 15. And, of course, we need only remind ourselves that less than two decades ago the typical major weapon system had an acquisition cycle of less than 8 years, or about half its current length.

In addition, what are the cost implications of a longer acquisition cycle? It is difficult to answer that in precise terms. But the Packard Commission report says that "time is money," that the excessively long cycle "leads to unnecessarily high cost," and that a significant reduction in the length of the acquisition cycle would result in a "concomitant" reduction in cost.

## CAN WE SELECT THE BEST SYSTEMS UNDER A-109?

In an environment of austere and declining budgets, many potential systems are competing for entry into the acquisition pipeline; but not all get in, leaving some of the Service requirements unfunded. But are we at least selecting the best systems from the available candidates? Also how does the current process of choosing major system new starts compare with the process we had in the '50s and '60s? To answer that question, we need to take a look at how the selection process is implemented.

In moving the entry gate from the start of FSD to the beginning of Concept Exploration, A-109 has effectively also moved the selection gate to that point in the cycle. At the start of Concept Exploration the requirements are stated, per A-109, in functional, rather than hardware, terms in order to preclude any preconceived hardware solutions from entering the picture. Since at this point we don't even know what the system is going to look like in terms of hardware, estimates of the two most critical parameters of the competing candidates, cost and performance, are bound to be extremely soft. Furthermore, the candidate that is least understood at the time will frequently appear to have the lowest cost and most attractive performance.

Thus, although the selection process is currently getting the benefit of top-level wisdom from OSD and Congress, that wisdom is being exercised in the dark, i.e., under virtually total lack of visibility into the two most critical system parameters. This leads us to the conclusion that we are probably not now selecting the best of the competing candidates.

## CONCLUSIONS

The formalization of the Concept Exploration and Demonstration/Validation phases, and the accompanying early involvement of the Secretary of Defense and Congress, gave OSD tighter control over the major programs coming into the acquisition pipeline as well as over the first two phases wherein the bulk of system life cycle cost is locked in. In other words, the last two decades have witnessed very tight top-level management control over the acquisition process, not only from cradle to grave but, literally, from conception to grave. But at what price? The price appears to be a doubling of the length of the acquisition cycle for major system, a "concomitant" increase in cost, and a squandering of our five-year technological edge on the battlefield. In addition, we are probably not selecting the best systems from the competing candidates for entry into the acquisition pipeline.

Are the benefits of the tight top-level management worth the price we are paying for them? Are we engaging in a management overkill? Perhaps consideration should be given to modifying some of the provisions of A-109. For instance, should the approval of the early milestones and oversight of the associated phases be delegated to a much lower management level? And should OSD and Congress be brought into the decision process only after reasonable visibility into cost and performance of the candidates becomes available? Such an approach would parallel the management practices of many of the excellent firms in the commercial sector, where during the last two decades the trend has been not to over-manage new programs in their infancy.


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# COST AND SCHEDULE GROWTH IN MAJOR ACQUISITION PROGRAMS: AN EMPIRICAL ANALYSIS

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## ABSTRACT

The paper summarizes descriptive trends in outcomes for major system acquisition programs, including similarities and differences based on equipment type, time period, program type (new vs. modification), and acquisition initiatives applied. Several factors that might affect cost growth for major systems are examined--among them, development schedule, equipment type, program type (new vs. modification), schedule length, acquisition initiatives, and production stretchout. The paper examines cost growth for a group of major systems including aircraft, missiles and munititions (tactical and strategic), and satellites. Growth was defined as actual cost relative to cost estimated at Milestone II full-scale development start.

The paper uses Selected Acquisition Report (SAR) data for 89 programs, development concept papers, and other information from the military services, program offices, and the defense industry.

The factors most closely associated with cost growth in total program are development schedule growth, program stretch, and development schedule length. Development schedule growth and program stretch in particular are consistent major drivers.

## INTRODUCTION

This paper summarizes descriptive trends in outcomes for major system acquisition programs. In addition, the factors most closely associated with cost growth are examined. A sample of 89 major acquisition programs was selected for analysis. The programs were selected to represent the following categories of equipment: tactical aircraft, electronic aircraft, helicopters, other aircraft, air-launched tactical munitions, surface-launched tactical munitions, electronics/avionics, strategic missiles, and satellites.

The sample includes acquisitions managed by the Army, Navy, and Air Force and both programs that are considered successful and those that encountered problems. The sample is spread over approximately 32 years when grouped by FSD start. Nearly all programs in the sample are either still in production and in service, or are previous versions of weapon systems that are still in production or in service. For the development analysis, we excluded programs fewer than three years past the start of full scale development. For the production analysis, we excluded programs with fewer than three years of production experience. For this analysis, we have at least some development information on 82 programs and at least some production information on 73 programs.

This paper is based on work performed for the Under Secretary of Defense (Acquisition).

## DATA SOURCES

For each of the programs included in the sample, schedule dates, cost, production quantities, and narrative information were obtained from Selected Acquisition Reports, and the latest available editions of the Defense Marketing Service (DMS) "Missile Market Intelligence Reports" [1], *Jane's Weapon Systems 1987-88* [2], the *Interavia* summary of weapons [3], and interviews with program management and contractor personnel.

Development estimates (DEs), made at Milestone II or at the start of full scale development, of schedules, costs, and quantities were obtained from the earliest available SAR for each program. Current estimates (CEs) of schedules, costs, and quantities were obtained from the December 1987 SAR (or the final SAR for completed programs). Development Concept Papers (DCPs) were reviewed to provide additional cost and schedule information in each program.

Representatives of selected contractors and program offices provided additional cost and schedule data and answered questions that surfaced during review of the SARs. These interviews greatly enhanced our understanding of individual programs.

## OUTCOME MEASURES

Outcome measures included:

- Cost growth--development, production, and total program.
- Schedule slippage--development and production. One indicator of good program performance is the extent to which the system can be developed and produced according to plan.
- Quantity changes--development and production. Trends in quantity change give clues to such issues as reasonableness of the development plan, the degree of production stability, and the prevalence of program stretchout.

Outcome measures produced were:

- Development cost growth (DCG)
- Production cost growth (PCG)
- Total program cost growth (TPCG)
- Development schedule growth (DSG)
- Production schedule growth (PSG)
- Development quantity growth (DQG)
- Production quantity growth (PQG).

In order to understand outcomes by program phase, we separate cost growth into development and production cost. Since production cost is much higher than development cost, it tends to drive our estimate of total program cost growth. However, development cost growth is also of interest, since it is here that the technical challenges are met.

The following process was used to produce development cost growth ratios:

- All program cost estimates were collected in the base-year dollars specified for the program.
- Development costs were determined for the period from program startup through initial operational capability (IOC) date. Development costs incurred after IOC were excluded because these costs were for major modifications and other changes beyond the scope of the original development effort.
- The development cost growth (DCG) ratios were calculated by dividing the current estimate of development cost at IOC date by the development cost estimate at SAR DE approval.

Many programs change their planned quantity as the program progresses through production. Therefore, some adjustment to costs is necessary to take quantity change into account. In this study, scope changes in most programs examined prevented direct comparison of SAR current estimates with the SAR development estimates. We developed price-improvement curves from the SAR annual data for completed production years. From these curves, we calculated the cost of the originally planned quantity, the development estimate quantity (DEQ). (Several programs examined do not have annual funding detail in the SARs that allow calculation of the current production estimate at the development estimate quantity. When no detailed data were available, the slope of the learning curve was assumed to be 90 percent.) IDA estimates of total production costs were then determined by adding the SAR current estimate of development costs at IOC date to the current estimate of production cost at the development estimate quantity. In the Hellfire program, total program cost at the DEQ is estimated to be $708.8 million. The total program cost growth ratio is then 1.39.

We also report estimates of schedule slippage in development and production. Schedule growth during development of a new weapon system is normally measured by the amount of slippage experienced in a program between a fixed base date (e.g., Milestone II date or FSD contract start, whichever is earliest) to initial operational capability (IOC). After the necessary data were collected, the development schedule growth (DSG) ratio was computed as the ratio of actual to estimated development time.

Production schedule is determined using the same technique. Production span is defined as the period from Milestone III or first production contract to production end date or the last fiscal year of planned funding. Production schedule growth (PSG) ratios are computed as the ratios of actual to planned (DE to CE) time for production.

Both development quantity and production quantity changes were documented using the same technique described above.

## DISCUSSION OF PROGRAM OUTCOMES

Weapons acquisition programs had varying degrees of success in accomplishing cost, schedule, and quantity objectives. Table 1 shows selected results from our database. Although many acquisition programs have been successful, others have encountered serious problems, in spite of numerous policy changes and initiatives intended to improve the acquisition process.

### Outcomes by Time Period

The time periods analyzed are the 1960s, the early 1970s, the late 1970s, and the 1980s. Each of these periods had different acquisition policies and initiatives. In the 1960s, the idea of program management was just beginning. Initiatives used included total package procurement and concurrency. Management was centralized within OSD. In the early 1970s, the prevalent initiatives, with the influence of Deputy Secretary of Defense David Packard, included incentive contracting, prototyping, and design-to-cost. In the late 1970s, design-to-cost became institutionalized, and experiments with dual-sourcing in tactical munitions were tried. In the 1980s, initiatives included fixed-price development, multi-year procurement, and more dual sourcing.

Table 1. Statistics on Key Variables

| | N | Mean | Minimum | Maximum | Standard Deviation |
|---|---|---|---|---|---|
| Total Program Cost Growth[a] | 63 | 1.51 | 0.76 | 5.19 | 0.76 |
| Development Cost Growth[a] | 80 | 1.27 | 0.44 | 4.89 | 0.73 |
| Production Cost Growth[a] | 63 | 1.65 | 0.69 | 6.61 | 1.03 |
| Development Schedule Growth | 81 | 1.34 | 0.76 | 3.90 | 0.50 |
| Production Schedule Growth | 57 | 1.65 | 0.63 | 3.71 | 0.78 |
| Development Quantity Growth | 76 | 1.12 | 0.50 | 4.10 | 0.61 |
| Production Quantity Growth | 63 | 1.22 | 0.02 | 4.76 | 0.88 |
| Development Schedule Length (months) | 77 | 79.1 | 19.0 | 147.0 | 31.62 |
| Production Schedule Length (months) | 56 | 127.1 | 32.0 | 311.0 | 64.29 |

[a]Cost growth ratios are weighted by 1989 dollar values for total program, development, and production, respectively.

We grouped programs into time periods according to their FSD starts because FSD is a major milestone and acquisition strategies are often determined by that point. Therefore, it seems reasonable to conclude that policies at the time of FSD have the most influence on a program. However, a typical program continues for over ten years past FSD, so it may be influenced by the policies of other periods as well.

We compare observed results in terms of cost and schedule with estimates at the time of full scale development. Table 2 shows cost, schedule, and quantity outcomes by time period.

The 1960s, when SAR cost estimation was in its infancy, was a period of high cost growth. Major programs such as the C-5A aircraft and the Minuteman missile were being developed. In addition, methods of tracking and managing programs were less highly structured than today [4]. The cost growth in the 1960s was higher than in the early 1970s. Development schedule growth was also higher in the 1960s than in later periods.

Programs with FSD start in the early 1970s, the time of the Packard initiatives, had good overall records. Cost growth both in development and in production was relatively low; however, the number of programs started in this time period was also relatively low.

Programs with FSD starts in the late 1970s did not do well. Their overall cost growth was almost as high as in the 1960s (1.60 versus 1.66.) Development schedule growth was a problem (1.37), although not as bad as in the 1960s (1.46). The late 1970s were a time of high inflation and declining budgets, which may have influenced cost growth. When the 1970s are considered as one period, the differences between periods are less pronounced.

The jury is still out on programs begun in the 1980s. In terms of development, the 1980s programs show lower development cost growth than past programs. However, this difference is not statistically significant. The early 1980s were a time of expanding acquisition budgets and low inflation, which may also have contributed to favorable development outcomes. Only five programs (the AV-8B aircraft, the OH-58D helicopter, the C-5B transport, the B-1B bomber, and the E-6A aircraft) had sufficient production data to be included in the analysis. All of them are modifications of prior programs and thus could be expected to have lower cost growth. In addition, the five programs are in the early stages of production and have not had much time to accumulate cost growth.

The stage of program completion also affects cost growth. It takes time for programs to revise cost estimates as problems arise. Table 3 shows mean cost growth for complete and incomplete programs. Cost growth is substantially higher in the completed programs. Mean total program cost growth is 1.92 for completed programs and 1.30 for incomplete programs.

Table 2. Summary of Cost and Schedule Outcomes by Time Period

| Time Period | N | DCG | DSG | DQG | N | PCG | PSG | PQG | TPCG |
|---|---|---|---|---|---|---|---|---|---|
| 1960s | 22 | 1.36 | 1.46 | 1.17 (20) | 21 | 1.89 | 1.64 (18) | 1.00 | 1.66 |
| Early 1970s | 12 | 1.25 | 1.24 | 1.33 | 11 | 1.42 | 1.84 (9) | 1.15 | 1.37 |
| Late 1970s | 30 | 1.28 | 1.37 | 1.01 | 26 | 1.73 | 1.69 | 1.50 | 1.59 |
| 1970s (total) | 42 | 1.26 | 1.33 | 1.10 | 37 | 1.63 | 1.73 (35) | 1.40 | 1.51 |
| 1980s | 17 | 1.16 (16) | 1.21 | 1.09 (14) | 5 | 0.91 | 1.07 (4) | 0.85 | 0.92 |

Note: Cost growth figures are dollar-weighted. Figures in parentheses are numbers of programs for cells with missing data.

Table 3. Complete Versus Incomplete Programs

| | No. of Programs | Complete Programs | No. of Programs | Incomplete Programs |
|---|---|---|---|---|
| TPCG | 23 | 1.92 | 33 | 1.30 |
| PCG | 23 | 2.24 | 33 | 1.34 |
| PQG | 23 | 0.36 | 33 | 1.47 |
| PSG | 22 | 1.49 | 32 | 1.82 |
| DCG | 23 | 1.42 | 41 | 1.18 |
| DSG | 23 | 1.59 | 42 | 1.24 |
| STRETCH | 22 | 3.71[a] | 32 | 1.67 |

Note: Cost growth figures are dollar-weighted.
[a]Condor (STRETCH = 56) excluded.

Dews et al. [5] also found that cost growth tended to accumulate in production for a sample of 1970s programs. Cost growth accumulates gradually as experience is gained, and cost estimates have to be revised to reflect experience. If the end of the production run is more than five years into the future, then cost estimates for the out-years would not appear in the FYDP and might not be revised immediately.

Other caveats about the 1980s programs include:

- The relative need to "sell" a program at a given time may influence the initial development estimate of both cost and schedule. When budgets are fairly generous and expected to increase, obtaining funds is relatively easy, so there is no incentive to underestimate. However, if budgets are tight, there may be an incentive to underestimate costs in order to get the program funded.
- We have only six 1980s programs, and we have on average only four to five years of production data for them. If cost growth tends to appear late in the program, then these programs should be reevaluated when they have more experience.

Outcomes by Equipment Type

Table 4 shows cost and schedule outcomes by equipment type. Tactical munitions programs have experienced the highest total program cost growth of any class of system examined. Air-launched tactical munitions experienced the second highest development cost growth (1.69) and the highest production cost growth (2.32). Surface-launched tactical munitions fared somewhat better than air-launched munitions in development (1.34), but also experienced considerable production cost growth (2.31).

Experience with other equipment types generally were much better. Aircraft, satellites, and strategic missiles tend to have lower total program cost growth than tactical munitions.

Electronics programs exhibited the highest cost growth in development. They were examined only for development cost growth because we could not disaggregate production costs from the SARs. However, the rationale that applies to cost growth for munitions programs very likely applies to electronics programs as well.

Outcomes by Program Phase

We examined cost growth in development and in production separately. From Table 1, we can see that cost growth is less on average in development (1.27) than in production (1.65). This may be because there is less time between the estimate and the actuals in development--by the time production is completed, by contrast, the DE may be 15 years old or more. The estimate of total program cost growth is heavily influenced by production cost growth. Our quantity-adjusted production cost is on average 3.5 times the size of development cost in real terms.

Table 4. Summary of Cost and Schedule Outcomes by Equipment Type

| Equipment Type | N | DCG | DSG | DQG | N | PCG | PSG | PQG | TPCG |
|---|---|---|---|---|---|---|---|---|---|
| Tactical Aircraft | 8 | 1.18 | 1.03 | 1.10 (7) | 8 | 1.25 | 2.12 (7) | 1.65 | 1.23 |
| Electronic Aircraft | 9 | 1.37 | 1.16 | 1.21 (8) | 9 | 1.27 | 1.49 (6) | 1.07 | 1.28 |
| Other Aircraft | 5 | 1.09 | 1.14 (6) | 0.83 (4) | 4 | 1.50 | 1.06 (3) | 0.74 | 1.39 |
| Helicopters | 5 | 1.36 | 1.16 | 0.93 | 4 | 1.46 | 1.01 | 0.95 | 1.39 |
| Air-Launched Tactical Munitions | 16 | 1.69 | 1.68 | 1.43 | 15 | 2.32 | 2.16 (14) | 1.42 | 2.05 |
| Surface-Launched Tactical Munitions | 18 | 1.34 | 1.42 | 0.95 | 12 | 2.31 | 1.49 | 0.87 | 2.08 |
| Electronics/Avionics | 7 | 1.75 | 1.27 | 1.39 | 0 | - | - | - | - |
| Strategic Missiles | 8 | 1.15 | 1.34 | 0.87 (7) | 7 | 1.58 | 1.39 | 1.47 | 1.37 |
| Satellites | 4 | 1.37 | 1.26 | 1.00 | 4 | 1.15 | 1.36 | 1.35 | 1.20 |

Note: Cost growth figures are dollar-weighted. Figures in parentheses are numbers of programs for cells with missing data.

Schedule growth in development goes hand-in-hand with cost growth in production--there is a .540 correlation between the two (statistically significant at .0001). Development schedule growth is also associated with total program cost growth (.611 correlation, statistically significant at .0001).

In electronic aircraft and in satellites (Table 4), cost growth is higher in development than in production. One might hypothesize that this is because of the higher content of technology in these items. However, tactical munitions have similar technical content, but cost growth is higher in production than in development.

The highest development cost growth is in electronics/avionics (1.75), for which we have no corresponding measure of production cost growth. The second highest is in air-launched tactical munitions (1.69), which makes sense considering the technical risks involved and the difficulty in selling these less-glamorous programs.

Outcomes by Program Type

Finally, we analyzed program outcomes for both new development programs and modification programs. The purpose of this analysis is to see whether outcomes are substantially different between new and modification programs. Table 5 shows cost and schedule outcomes for new and modification programs.

As would be expected, modification programs have exhibited better cost growth experience than new programs. Within individual equipment types, there were some exceptions to this general rule. Air-launched tactical munitions modification programs have experienced the highest development cost growth of any class of system examined. Costs for tactical munitions modifications are usually underestimated, because a modification often comprises a new guidance and control system, the largest part of the equipment cost.

Electronic aircraft modification programs exhibited higher cost growth in both development and production phases then new electronic aircraft. Again, this can be attributed to underestimation of the technical difficulty and the cost of integrating the electronics equipment with the airframe.

## FACTORS ASSOCIATED WITH COST GROWTH IN MAJOR PROGRAMS

We turn to a closer look at cost growth, a major concern of both DoD and Congress. We examine here some of the reasons for higher or lower cost growth. Why do some programs exhibit relatively high cost growth, while others keep closer to their plans? Program stretch has become more common over time. It is frequently suggested that stretch has been a major contributor to cost growth. We examine these claims. Acquisition initiatives are often designed to reduce cost growth. We look at the impact of these initiatives on cost growth using the database of SAR programs.

Finally, other potential contributors to differences in cost growth are examined. While our examination is limited by the data, we believe that this is an important opportunity to examine the drivers of cost growth in a large sample of programs.

Program Stretch as a contributor to cost growth

We examined the hypothesis that program stretch contributes to cost growth, particularly to production cost growth. The Defense Department and the Congress have sometimes met budgetary constraints by stretching out the production schedule buying the same quantity over a longer schedule, or buying a lesser quantity over the same time period.

We measured program stretch by the ratio of production schedule growth to production quantity. A normal value of stretch is 1.0. This indicates that schedule and quantity either did not grow, or grew in proportion with one another. A stretch value of two indicates that the program relatively doubled in schedule while buying the same quantity.

Our results indicate that program stretch is a significant determinant of both production and total program cost growth. Table 6 shows regression results for two different data sets--the full data set and a data set with outliers (defined as values more than two standard deviations from the mean) removed. (Outliers can have a large influence on regression estimates. In some cases, the removal of outliers can change an equation drastically. The outliers in this equation were SRAM, Roland, and Condor.)

In both data sets, stretch is statistically significant. To interpret the coefficients, we use the unweighted PCG estimate from the full data set as an example. With STRETCH=1 (the norm), PCG is estimated by:

$$1.41 + (0.094*1) = 1.504.$$

If STRETCH=2, then PCG is estimated by:

$$1.41 + (0.094*2) = 1.598.$$

Table 5. Summary of Cost and Schedule Outcomes by Program Type

| Program Type | N | DCG | DSG | DQG | N | PCG | PSG | PQG | TPCG |
|---|---|---|---|---|---|---|---|---|---|
| New | 48 | 1.30 | 1.34 | 1.05 (47) | 37 | 1.69 | 1.63 (35) | 1.13 | 1.54 |
| Mod | 32 | 1.20 | 1.35 (33) | 1.23 (29) | 26 | 1.57 | 1.68 (22) | 1.36 | 1.46 |

Note: Cost growth figures are dollar-weighted. Figures in parentheses are Ns for cells with missing data.

Table 6. Regression Results for Program Stretch

| | Intercept | Stretch | $R^2$ | N |
|---|---|---|---|---|
| Production Cost Growth | | | | |
| With Full Data Set | | | | |
| Unweighted | 1.41 | 0.094[a] (6.26) | 42 | 57 |
| Weighted | 1.36 | 0.097[a] (8.55) | .57 | 57 |
| With Outliers Removed | | | | |
| Unweighted | 1.30 | 0.085[b] (2.03) | .07 | 54 |
| Weighted | 1.28 | 0.094[b] (2.39) | .10 | 54 |
| Total Program Cost Growth | | | | |
| With Full Data Set | | | | |
| Unweighted | 1.37 | 0.070[a] (6.56) | .44 | 57 |
| Weighted | 1.30 | 0.073[a] (7.83) | .53 | 57 |
| With Outliers Removed | | | | |
| Unweighted | 1.27 | 0.080[b] (2.16) | .08 | 54 |
| Weighted | 1.19 | 0.098[a] (2.94) | .14 | 54 |

Note: Numbers in parentheses are t-statistics.
[a]Significant at .01 level.
[b]Significant at .05 level.

Thus, using this equation, each one unit increase in stretch is associated with an increase of .094 in the production cost growth ratio, or 9.4 percentage points. Other estimates ranged from 7 to 10 percentage points. These are in line with estimates found in a report on stretch by the Congressional Budget Office [6], which surveyed assessments of the military services and weapons producers. These estimates ranged from around 8 percent to over 50 percent for each unit increase in stretch.

Acquisition Initiatives to Improve Program Outcomes

We used regression analysis to examine whether the acquisition initiatives we studied are associated with lower cost growth. We analyzed the full data set and the following subsets of equipment types:

- Aircraft--includes tactical aircraft, electronic aircraft, helicopters, and other aircraft.
- Tactical munitions--includes air-launched and surface-launched tactical munitions.
- Other--includes electronics/avionics (development only), strategic missiles, and satellites.

The initiatives included multi-year procurement, competition in production, prototyping, design-to-cost, total package procurement, fixed-price development, contract incentives in development, and contract incentives in production.

In all cases, the dependent variable was cost growth, whether development, production, or total program cost growth. Fixed-price development was tested only in development, since none of the FPD programs was far enough along in production to be included. Table 7 gives only those results for which the initiatives were statistically significant.

In development, fixed-price development appeared to contribute to increased cost growth for the "other" category of programs. However, this variable was significant only at the .10 level, and it is based on limited data. In the same category, contract incentives in FSD were related to reduced development cost growth (significant at .05).

In production, total package procurement was related to increased cost growth for the full data set and for aircraft and other programs. In the "other" category, incentives in FSD were related to reduced production cost growth (.10 significance).

With respect to total program cost growth, total package procurement again was related to increased cost growth. In the "other" category, incentives in FSD and in production were both related to reduced total program cost growth.

These results have some limitations. This is an aggregate analysis, and for some initiatives, aggregate comparisons may not be the most appropriate. This analysis is based solely on the criterion of whether an initiative was applied or not. There is nothing to indicate how strongly or appropriately the initiative was applied. For example, all instances of design-to-cost, whether strongly applied or not, are included. A more detailed analysis of the initiatives is contained in an IDA report prepared for the Under Secretary of Defense for Acquisition [7].

Explaining Acquisition Cost Growth

Using our database, we investigated factors that might account for or be considered drivers of total program cost growth. These included:

- Cost and schedule growth in development. One hypothesis is that a smooth development process (on time and on cost) would make smooth production more likely. Programs that get into difficulty in development might be more likely to have problems overall.
- Equipment type. In this study, we analyzed a variety of equipment types. Tactical munitions appeared to have higher cost growth than other systems.
- New starts versus modifications of existing systems. It might be expected that new starts are riskier and thus more subject to cost growth pressures.
- Acquisition initiatives. Specific initiatives by the Department of Defense that have targeted program cost may have an impact.
- Schedule length. Long programs have more opportunity to accumulate cost growth.
- Program stretch. Buying the same quantity over a longer period of time may increase cost growth.

We tested several formulations of the candidate variables. Significant results are reported in Table 8. Development schedule growth, program stretch, and development schedule length are the strongest determinants of total program cost growth that we found. All work in the direction of increasing total program cost growth.

Table 7. Regression Results for Acquisition Initiatives

| Outcome Measure | Programs | Initiative | Intercept | Coefficient | $R^2$ | N |
|---|---|---|---|---|---|---|
| TPCG | Aircraft | Total Package Proc. | 1.22 | 0.54[b] (2.03) | .15 | 25 |
| TPCG | Other | Total Package Proc. | 1.32 | 2.07[a] (5.94) | .80 | 11 |
| TPCG | Other | Incentives, FSD | 2.21 | −0.96[a] (−2.52) | .41 | 11 |
| TPCG | Other | Incentives, Prod | 1.94 | −0.79[b] (−2.19) | .35 | 11 |
| PCG | All | Total Package Proc. | 1.57 | 1.27[a] (2.13) | .07 | 63 |
| PCG | Aircraft | Total Package Proc. | 1.21 | 0.94[a] (3.15) | .30 | 25 |
| PCG | Other | Total Package Proc. | 1.36 | 4.16[a] (13.71) | .95 | 11 |
| PCG | Other | Incentives, FSD | 2.88 | −1.57[b] (−2.08) | .32 | 11 |
| DCG | Other | Fixed Price Dev | 1.51 | 1.60[b] (2.05) | .20 | 19 |
| DCG | Other | Incentives, FSD | 2.00 | −0.77[a] (−2.23) | .23 | 19 |

Note: Numbers in parentheses are t-statistics.
[a]Significant at .05.
[b]Significant at .10.

Table 8. Drivers of TPCG

| | Intercept | DSG | Stretch | TPP | DS | $R^2$ | F | N |
|---|---|---|---|---|---|---|---|---|
| Full Data Set | 0.634 | 0.573 (4.36) | 0.053 (5.20) | – – | – | 0.59 | 37.66 | 56 |
| | 0.374 | 0.427 (3.34) | 0.054 (5.85) | 1.124 (3.32) | 0.005 (2.36) | .68 | 26.41 | 55 |
| Data Set with TPCG Outliers Removed | 0.779 | 0.390 (4.02) | 0.070 (2.13) | – – | – – | 0.30 | 10.89 | 53 |
| | 0.560 | 0.300 (3.06) | 0.070 (2.23) | – – | 0.004 (2.60) | .38 | 9.86 | 52 |

Notes: All results are significant at .05 level. Numbers in parentheses are t-statistics.

## CONCLUSIONS

There is little indication that acquisition program outcomes are getting either substantially better or substantially worse. Development schedule growth and cost growth in development, production, and the total program remain persistent problems, even though considerable improvements have been made in the information available to program managers. The early 1970s, the time of the Packard initiatives, seems to have better program outcomes than other periods.

Our conclusions about programs begun in the 1980s are preliminary. We are reluctant to draw any conclusions about the production phase because of the small number of programs in our sample and because those programs are all in the early stages of production.

Program outcomes differ depending on equipment type. Tactical munitions programs experienced the highest total program cost growth. This was foreshadowed by their cost and schedule problems in development. Electronics/avionics programs had the highest development cost growth of any equipment type. We were unable to track the production experience of electronics/avionics systems due to data limitations--production data is usually included in the platform SARs and cannot be disaggregated. However, we have seen that problems in development tend to be followed by production problems. This, coupled with the fact that many future programs emphasize avionics heavily, suggests that these programs should be targeted for increased management attention.

As expected, modification programs exhibited lower total program cost than new programs. It is easier to stay on plan for a modification program. However, there are two equipment types for which this was not the case--air-launched tactical munitions and electronic aircraft. Both of these emphasize guidance systems or avionics and further reinforce our conclusions that these are particular problem areas.

We examined the hypothesis that program stretch contributes to cost growth. We found that stretch adds 7 to 10 percentage points to production cost growth in real terms. Thus, the decision to fund more programs in the face of limited budgets means a loss of efficiency.

The acquisition initiatives we studied were designed to reduce costs. We examined how these initiatives were related to cost growth. Three of the acquisition initiatives had a statistically significant relationship with cost growth for some equipment types. These include:

- Contract incentives in FSD and in production, which were associated with lower cost growth.
- Total package procurement, which was related to increased production and total program cost growth.
- Fixed-price development, which was associated with higher development cost growth.

However, this sort of aggregate analysis is not the final word. We measured here only whether an initiative was applied or not, not how effectively it was applied.

We examined several factors that might account for or be considered major drivers of cost growth. Among all of these factors, three stand out. The major drivers of total program cost growth appear to be development schedule growth, program stretch, and development schedule length.

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Defense Program Lifecycle Management:
A System Dynamics Model for Strategic Analysis

by

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Abstract

Program lifecycle management is of prime importance to firms, such as Hughes Aircraft Company, that design, manufacture, and maintain complex military equipment and systems. These firms have come under increasing government scrutiny and control, particularly with regard to cost and schedule risks. The Electro-Optical and Data Systems Group of Hughes has worked with the Systems Dynamics Laboratory at the University of Southern California (USC) to develop a system dynamics model for analyzing alternative policies available to a defense contractor for managing the production program lifecycle.

The project to develop the lifecycle model was initiated in 1985 in order to analyze the over-time impact of design changes on cost, schedule, and technical performance. The model was developed on the premise that program management is a process with continuous flows and discrete steps. By understanding the relationships among these steps and flows, second and third order effects of various management policies on the acquisition process can be examined. The Hughes-USC model addresses the construct that cost and schedule risks can be substantially reduced through improved program management information, even in the event of external delays and disruptions caused by customers, vendors, and suppliers. For example, the model suggests that overruns, particularly cost overruns, may be significantly reduced - without adversely affecting product quality - by carefully limiting the number and type of discretionary mid-production design improvements.

This paper reports the background, approach, basic structural elements of the Hughes-USC model, and highlights some of the findings that have emerged from the policy testing phase of the development.

## Background

The Electro-Optical and Data System Group (EDSG) at Hughes Aircraft Company has become increasingly aware of the need to improve the efficiency of the process with which its production programs are implemented. Inefficiencies in the implementation process may accumulate over the entire program lifecycle to raise costs, extend schedules, impact product quality or otherwise reduce customer satisfaction.

A number of these inefficiencies can be traced to the customer's demand for full-scale production even while the product design is still somewhat immature or while the customer's needs have yet to be defined clearly. Since the customer also demands a high-quality, reliable product, the product design may have to be changed and upgraded in the midst of full-scale production. But design changes can have an enormous impact and affect virtually every aspect of the program lifecycle. For this reason, the manner in which changes are made, communicated, released, and incorporated may have a great influence on a program's overall relative success.

It is the primary function of Configuration Management (CM) to direct and control the flow of vital product information throughout the lifecycle of program implementation. The primary objectives of Configuration Management include the following:

a. To assist management in developing and producing systems and/or equipment that achieve the required performance at the lowest cost, within the scope of the contractual requirements, and consistent with the goals and objectives of the company.
b. To maximize the return from development and production effort by allowing the greatest degree of design and development latitude consistent with the appropriate degree of configuration control.
c. To establish a documented initial statement of technical requirements and to establish approved and controlled technical documentation for use in the development, manufacture and logistic support of systems/equipment.
d. To ensure configuration identification and correlation of documentation and hardware items by means of a uniform, standard system of identification numbers.
e. To attain maximum efficiency in the management of configuration changes with respect to their necessity, cost, timing and implementation.
f. To ensure correlation between configuration identification and the equipment.
g. To attain the optimum uniformity in configuration management policy, procedures, forms, reports, and data.

This function would be important even without design changes, because of the inherent logistical challenge of managing both internal and external relationships in such a way that lines of communication and material pipelines function smoothly and so that cost-effectiveness is maintained.

The challenge of CM is compounded greatly, however, in the presence of mid-production design changes, particularly when these changes are numerous and continuous. The incorporation of design changes by manufacturing can be disruptive and may even lead to higher costs and more schedule slippages if not appropriately managed. But the meaning of "appropriate management" in this dynamic context is unclear. For example, is it more cost and time effective to block changes, i.e., accrue to some number before their release, or to release changes individually as they are approved? Likewise, is it better to scrap old parts in inventory to make way for the new and improved components, or to avoid the cost and disruption of scrapping by using the old parts?

Because of the sheer complexity of program implementation, the answers to such questions are far from obvious. At the same time, the importance of finding and acting upon the answers is undeniable.

Purpose and Approach

This EDSG project began as a research study and has evolved into an operating model with several completed phases. Its purpose is to examine the potential role of CM in making program implementation more efficient over the entire lifecycle of design, manufacturing, and Integrated Logistics Support (ILS). The initial phase was devoted to the construction, refinement, and calibration of a system dynamics computer simulation model. This model portrays the major flows of materials and information in the overall implementation system, as well as the decisions and actions that are responsible for those flows. A major portion of this phase was devoted to sensitivity testing of the model, a process which reveals the key pieces of causal structure underlying observed behavior, and which indicates the key decision points in the system. The model that has been developed permits examination of alternative policies and programs in the quick, inexpensive, risk-free environment of a computer program, so that resources can later be spent more effectively in the real system. Figure 1 describes the interfaces, material flows, and information flows in the system.

Figure 1 - Model Overview diagram here

The second phase consisted of two major actions - alternative policy testing for optimal production strategies within the realm of management and verification of the model structure by applying it to a completed production program and comparing the model output with the historical outcomes which were known. In this "hindsight" application, the model predicted accurately the outcome of the acquisition. The impacts of exogenous and endogenous events that occurred during the project were tracked with a high degree of accuracy. The results of the two phases will be presented in the following discussion.

Description of Model Structure

Model development and sensitivity testing are necessary precursors to an in-depth analysis of CM policy alternatives. This subsequent analysis will be used to shape policies that will guide decision making for specific programs at EDSG. It is conceivable that a set of decisions that is best for one program may not be best for another.

The model described in Figure 1 consists of roughly 300 parameters, including 200 output variables and 100 input parameters (fixed constants and functional forms). These parameters are discussed in detail in Part 2 of this report. Of all the input parameters, only the Master Schedule for shipments actually "drives" the system through time; all other inputs are time-independent. The model is written in the DYNAMO simulation language as a set of integral equations which approximate the continuous movement of the system through time. As characterized in Figure 1, the model portrays the major program implementation activities within EDSG as well as interactions with the customer and with parts vendors. The EDSG system consists of three functional subsystems - Engineering, Manufacturing, and ILS- involved in implementing a program that has been given its production contract "go-ahead".

The function of Engineering as modeled is to respond to engineering change requests (ECRs) with design (engineering) changes, in the form of new drawings that are passed on to Manufacturing for incorporation. ECRs may be submitted as a result of input from the customer (new performance requirements), from Engineering itself (continued design improvements), from Manufacturing (test yield or producibility problems), or from ILS (reliability problems). It is assumed in the model that the need for further design changes can ultimately be eliminated as the design improves toward its ultimate "ideal" state relative to the customer's requirements.

The function of Manufacturing as modeled is to procure and fabricate component parts and to assemble, test, and (when necessary) to rework units. Assembled units that have passed final test, or whose test requirements have been waived, are then shipped to the customer via ILS. (Waivers may allow lower quality units to be shipped and are therefore turned to in large numbers only when shipments are running significantly behind schedule.) Also shipped to ILS are spare parts used for unit repairs.

The ordering and fabrication of parts and the assembly of units are driven largely by the Master Schedule for shipment (set back in time to account for normal lead times). Purchase and fabrication orders may exceed their scheduled quantities, however, when stocks are depleted or backorders have developed. These conditions may occur either because of an unexpectedly large demand for parts (for in-house rework and/or for spare parts) or following the purging (scrapping) of old configuration parts. Unit assembly may also be forced to deviate from schedule due to shortages of component parts (which can cause assembly slippages) or in an effort to make up for past slippages. Deviations allowing for the use (rather than purging) of old parts are also used more frequently when assembly schedule slippages become serious, in an effort to avoid further slippages.

The function of ILS as modeled is to repair field units that have failed and to procure the spare parts (from manufacturing) needed for repairs. Spare parts orders increase beyond their scheduled quantity when the rate of field failure exceeds expectations, in an effort to avoid spare parts shortages. Such shortages can lead to an increasing backlog of units awaiting repair with a corresponding decline in the Customer's field performance requirements.

Scope of the Model

The focus of the model was on the manufacturing and ILS phases of the production lifecycle. The central theme of the simulation was to study the effects of design imperfections detected at mid-production on program costs and schedule. The commonplace occurrence of concurrent production contracts, with the inherent incomplete designs and testing prior to full scale production, support this theme. Thus, the variables of interest were those that would affect such outputs as flows of parts, assembled units, rework, and engineering changes.

The model was developed and calibrated to represent an on-going production program that was nearing the mature stage of its lifecycle. A significant number of deliveries had occurred and follow-on awards had been received. The program was experiencing considerable schedule and cost overruns. After calibration, the model was able to track closely the historical data from the program. Various programmatic policies were then tested and the results were analyzed. When confidence in the model's ability to replicate the program was gained, the model was recalibrated to represent a different production program that had been completed and for which history and outcomes were known. Again, the model was able to closely represent the history of the program, including several scope changes that, in reality, did occur. As will be shown, the policy tests affected both programs in a similar manner, but of differing magnitudes in cost and schedule impacts.

Central Policy Issues

As indicated, the model was tested for many different programmatic policies. The impacts of these policies ranged from no economic benefit to very high impact. The three selected policies that will be discussed showed significant impact on cost and scheduled deliveries. These policies, although independent of each other, did produce additive benefits when applied collectively. The policies and an explanation of each are:

A. Mid-production engineering change requests (ECRs): ECRs are generated for a number of reasons including: a) new performance requirements, b) design improvements, c) test yield and producibility, and d) reliability. Two types of ECRs exist-class 1 and class 2. Class 1 ECRs are those that affect "form, fit, function, or safety" of the product. Class 2 ECRs tend to be those that deal with cosmetic change, typographical errors in drawings, etc., all very important to the management of the production configuration. For the purposes of this study, all class 1 changes were not considered within the scope of the model.
   Analyses have demonstrated that most class 2 ECRs are internally generated rather than customer directed. Questions that would arise are: Should discretionary ECRs be terminated altogether at some point during production? Should each ECR be accepted only if the economic benefit exceeds some threshhold? Should ECRs be grouped together and released in "blocks" rather than as processed and received?
B. Disposition of old-version parts: At issue is the fate of in-house parts when newer version parts are received. During production, it is commonplace for some of the components used in the manufacture of the product to have new and improved versions

offered by vendors. Sometimes, the new version becomes the only version available. Usually, when new version parts arrive in factory stores, it is a common practice to purge, or discard, old version parts from raw inventory and work-in-process. Not to do so may be considered a deviation from plan to cut new version parts into production as soon as possible. The question that arises is should the practice of purging be eliminated or modified?

C. Ordering of parts: Often, parts are purchased from vendors that have a great deal of uncertainty in delivery time. Some vendors may be small and have difficulty meeting large influxes of orders. It is a common practice to order parts so that most arrive well before they are needed for assembly (Antithesis of Just In Time inventory). This practice, allowing for early buildup of safety stock, is known as "front loading" the parts delivery schedule. In essence, the front loading exacerbates the constant problem of end-of-production part shortages by moving this problem forward in time. However, other problems dealing with inventory control such as parts attrition arise. The question then becomes should this practice be eliminated or modified in some manner?

Results of the Policy Testing

Tables 1 and 2 summarize respectively the policy test results for the mid-production and completed production programs.

Table 1. Mid-Production Program Results here

Table 2. Completed Production Program Results here

The three policies in each of the tables are listed in order of impact on the program variables. The most incremental impact was observed when the policy of completely eliminating purging of parts was invoked. In program 1, the gain in reducing cost overrun with this policy was 20%; with a net reduction in late deliveries (unit-months late) of 62%. Cutting off ECRs after the eighteenth month of production further reduced the cost overrun by 5% from plan, but an unexplainable increase in late shipments was observed. Finally, by employing the policy of elimination front loading, further improvement in reducing cost growth was noted, but a significant reduction of 50% in late shipments from the previous level was noted. Thus, when all of the three policies were implemented, cost improvement of 36% and schedule improvement of 80% were observed. Similar improvements are noted in the data from the second program.

Recommendations

The results of the policy testing utilizing the system dynamics model suggest the following recommendations:

1. Eliminate purging of old parts except where part changes are customer directed or as a result of a class 1 change; i.e., nondiscretionary. An understanding should be reached with customers on this policy so that use of old version parts is not considered a deviation from contract. Purging of the old parts can generate severe parts shortages largely responsible for cost and schedule problems. Purging parts actually slows the rate at which acceptable units are produced, counter to the intention.
2. Early termination of discretionary ECRs should be directed. Besides being a significant cost saver, reductions in schedule slippages will result. The marginal benefit of ECRs was found to decrease as design improves, but the marginal cost of the administration of the ECR remains the same. Thus, the marginal net benefit of ECRs is greater early in the manufacturing phase.

   The delays and disruptions caused by ECRs, especially those that have a high degree of interrelatedness, increases as production becomes more mature; further adding to the cost and schedule problems. Filtering out the less cost beneficial ECRs followed by an outright termination of all discretionary ECRs can cut costs more than termination alone. But, the

Table 1. Mid-Production Program Results.

| Policy | Relative Cost ($M) | % Cost Overrun* | Cumulative Late Deliveries |
|---|---|---|---|
| Current (Base) | 396 | 44 | 5670 |
| No Purging | 313 | 14 | 2155 |
| ECR Cut (Mo. 18) | 299 | 9 | 2223 |
| No Front Load | 298 | 8 | 1120 |

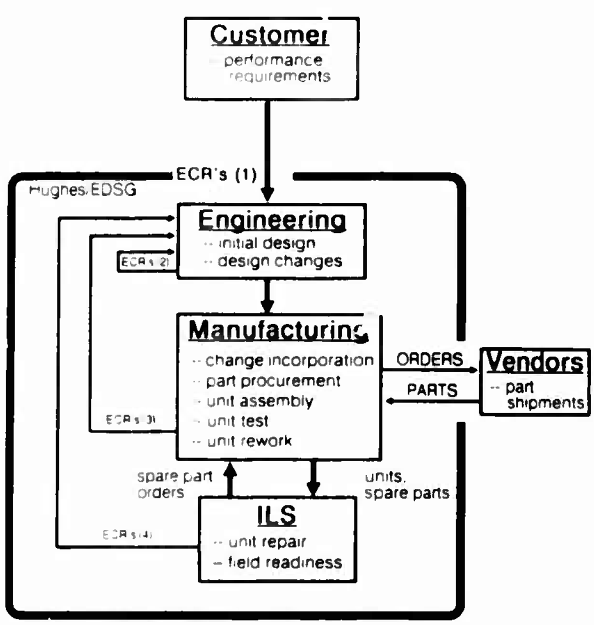
* based on plan

Table 2. Completed Production Program Results.

| Policy | Relative Cost ($M) | % Cost Overrun* | Cumulative Late Deliveries |
|---|---|---|---|
| Current (Base) | 193 | 33 | 2834 |
| No Purging | 175 | 21 | 2034 |
| ECR Cut (Mo. 18) | 160 | 10 | 982 |
| No Front Load | 157 | 8 | 976 |

* based on plan

**Figure 1 - Model Overview**




Sources of ECR's

(1) New performance requirements
(2) Design improvements
(3) Test yield and producibility
(4) Reliability

additional savings are relatively small and appropriate implementation is not an easy task. Thus, the benefits of filtering may not be worth the extra effort and uncertainty involved with such an action. Concerning the release of approved ECRs, it was determined that block release of mid-production design changes delays realization of their benefits and increases the disruption this method causes. The recommendation is that approved changes be released as they are processed and not be allowed to accrue.

3. The practice of front loading parts should be discontinued. Front loading of the parts delivery schedule builds up the raw parts stock and disguises the extra attrition caused by unexpected rework and repair - plus any impact of parts purging. This build-up can lead to the factory's being caught short of parts at the end of the contract should the production program be temporarily or permanently discontinued. Additional inventory carrying costs and control problems were not addressed in this simulation.

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# EFFECTIVENESS OF DESIGN-TO-COST IN MAJOR ACQUISITION PROGRAMS

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## ABSTRACT

Design-to-Cost (DTC) is a Packard initiative designed to develop a unit cost goal early in the design process. The concept requires that cost be weighted equally with performance and schedule. The study uses data on 63 major systems to compare cost and schedule outcomes for DTC and non-DTC programs. Case studies of the F/A-18 aircraft and the AH-64 helicopter, interviews with program office and industry staff were included in the analysis. Of the 63 major programs in the study, 27 programs have DTC application. The overall cost growth in DTC programs is 19 percentage points greater than that of the non-DTC programs. DTC has not been successful because it has been applied during FSD, too late in the program to be effective. DTC has been used as a cost monitoring device rather than as a design tool. However, in the late 1970's, when DTC had time to develop as an initiative, there are indications that it was more successful. To be cost effective, DTC should be implemented early in the concept development phase where design tradeoffs are still feasible.

## INTRODUCTION

The purpose of this paper is to examine trends in the outcomes (in terms of costs and schedules) of major system acquisition programs that have DTC implementation and to determine its effectiveness in improving these outcomes. The cost growth is examined by time period and by phases (development and production).

Our approach to this study is : (1) Develop cost and schedule histories of selected programs using Selected Acquisition Report (SAR) data, Development Concept Paper (DCP) information, and other information from the military services, program offices, and the defense industry; (2) Assess quantitatively the effectiveness of DTC in controlling or reducing cost, both at a macro-level (across all programs) and at a micro-level (on the basis of individual case studies).

## BACKGROUND

The design-to-cost (DTC) concept was instituted as one of several reforms to Department of Defense (DoD) procurement practices. Developed primarily by former Deputy Secretary of Defense David Packard and by former Director of Defense Research and Engineering (DDR&E) John Foster, DTC was an initiative designed to develop a unit cost goal early in the design process. DoD Directive 4245.3 of April 6, 1983 defines DTC as:

> an acquisition management technique to achieve defense system designs that meet stated cost requirements. Cost is addressed on a continuing basis as part of a system's development and production process. The technique embodies early establishment of realistic but rigorous cost goals, and thresholds and a determined effort to achieve them.

The DTC goal is initially expressed in terms of the average unit flyaway (or rollaway or sailaway) cost associated with an end item of military hardware. As the ability to translate operations and support cost elements into "design to" requirements improves, DTC goals and thresholds are related to total life-cycle cost (LCC).

In 1975, DoD Directive 5000.28 was issued imposing the concept of DTC on all major systems acquisitions, requiring that cost be weighted equally with performance and schedule. According to DoD Directive 5000.28 (1973), DTC has a twofold objective, as described below:

- To establish cost as a design parameter equal in importance to technical requirements and schedules throughout the development, design, production, and operation of the system.
- To establish cost elements as management goals for acquisition managers and contractors to achieve the best balance among LCC, acceptable performance, and schedule [1].

## BENEFITS AND WEAKNESSES

The primary benefit of DTC is the requirement that costs be estimated throughout the system's life cycle. Additional expected benefits are:

- DTC defines a measurable design parameter to be evaluated along with performance. A DTC parameter may be a goal or a threshold; values can be expressed in constant dollars, resources required, or other measurable factors that influence cost [2].
- DTC provides a basis for communication and coordination of effort between government and industry participants. [2]
- DTC leads designers and production engineers to take a design/production team approach during the design process.
- DTC provides strong motivation to restrain cost growth. Managers are reluctant to have to justify cost increases without good reasons. Likewise, contractors with incentives based on a specific cost goal will be hesitant to break through a cost ceiling knowing that it will cost them in profits.
- DTC can provide an early idea as to whether or not cost objectives will be met. DTC can do this because it tracks total system costs and can detect unsatisfactory trends early in the program.
- DTC can lead to more standardized components thereby providing the potential for significantly reducing costs.

In spite of all the expected benefits, the DTC concept also has some weaknesses. These are explained below [3]:

- DTC may result in cost goals being established too early. DTC forces the program manager to commit to a DTC goal well before final agreement on configuration and operational requirements. Hence, the need to "sell" the program may drive DTC goals down to unrealistic levels.
- DTC may stifle innovation and restrict the use of new technology. A contractor with a specified cost goal tends to use what works, rather than trying a new approach that may reduce costs but involves risk.
- DTC could cause suboptimization. The short term goal of meeting a specific cost ceiling may cause decisions that ignore long-term cost effects. When budget dollars and schedules are constrained, it is easy to ignore potential deficiencies because they will not be a problem for several budget periods, and then they will be someone else's problem.
- DTC may increase development costs. The concept requires sufficient development time and money to be used successfully.

## TYPICAL APPLICATION

DoD Directive 4245.3 requires the DTC goal to be established before Milestone I or at the earliest practical date thereafter, but in no case should the goal be established later than entry into FSD. Figure 1 illustrates DTC in the acquisition life cycle.

The staff of the Directorate for Procurement Policy examined over 35 contracts that used the DTC concept and found that about 40 percent had the DTC requirements implemented after the FSD contract was executed [4]. For example, the DTC goal for the F/A-18 was implemented after the program entered the FSD phase. In general, the DTC concept has not been properly applied. It has not been implemented early enough in the concept formulation phase, when greater flexibility existed to maximize total performance for the dollars available. In most programs, the DTC goal was not followed through to completion. It either was dropped or faded away in program FSD (F/A-18).

## DATA SOURCES AND OUTCOME MEASURES

For each of the programs included in the case studies and total sample, schedule dates, cost, production quantities, and narrative information were obtained from Selected Acquisition Reports, and the latest available editions of the Defense Marketing Service (DMS), "Missiles Market Intelligence Reports", Janes' Weapon Systems 1978-88, the Interavia Summary of Weapons, and interviews with program management and contractor personnel.

Development estimates (DEs) made at Milestone II or at the start of full scale development, of schedules, costs, and quantities were obtained from the earliest available SAR for each program. Current estimates (CEs) of schedules, costs, and quantities were obtained from the year-end SARs for the programs.

The outcome measures are as follows:

- Cost growth--development, production, and total program.
- Schedule slippage development and production.
- Quantity changes--development and production. Trends in quantity change given clues to such issues as reasonableness of the development plan, the degree of production stability, and the prevalence of program stretch-out.

Development cost growth is a ratio of the current estimate of development cost at IOC date and the development cost estimate at SAR DE approval.

Since many programs change their planned quantity as the program progresses through production, the production cost was calculated based on the originally planned quantity, the development estimate quantity (DEQ). We developed price-improvement curves from the SAR annual data for completed production years. From these curves, we calculated the cost of the development estimate quantity.

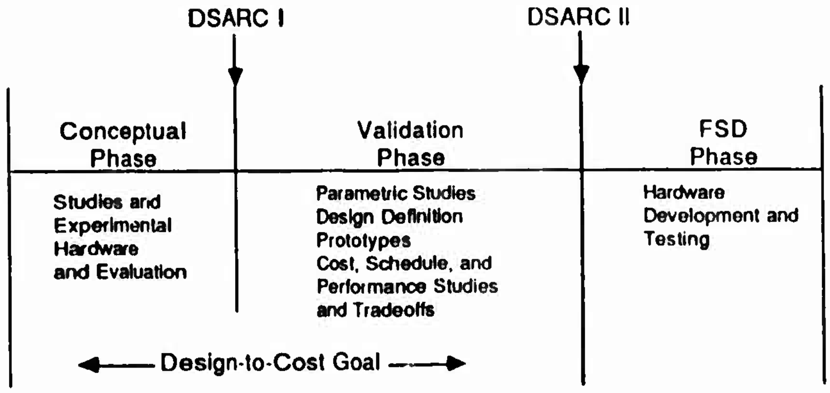


Figure 1. Design-to-Cost in the Acquisition Life Cycle

Development schedule growth is a ratio of actual time (months) from FSD to IOC. Production schedule growth is a ratio of actual time (months) from production start to production end and estimated time (months) from production start to production end.

CASES EXAMINED

The following cases illustrate the application of DTC in three systems, the F/A-18, the A-10, and the AH-64. Due to the relative availability of data, the cases presented vary considerably in scope and detail.

F/A-18 Aircraft

The F/A-18 program called for 11 RDT&E and 800 production aircraft. DTC was introduced as a requirement in the FSD contract awarded to McDonnell Douglas in January 1976. The contract also included a DTC incentive clause that provided for adjustments in FSD earnings for variations in cost from the DTC goals set down in the contract. In December 1978, production quantity was increased from 800 to 1,366, then was reduced to 1,157 in 1986. The F/A-18 has been significantly upgraded since its inception as a "low-cost" fighter.

The DTC goal was based on a cumulative average recurring cost for 800 aircraft. It was approved at $5.6 million ($5.9 million threshold) in FY 1975 dollars. Changes in program plan and schedule in 1978 revoked the DTC incentive arrangement. After that date, the government had no way to enforce DTC. The DTC reporting structure was maintained throughout FSD deliveries and eventually discontinued without a formal conclusion.

The cost summary of the F/A-18 program is given in Table 1.

Compared with all tactical aircraft in our study, the F/A-18 total program cost growth is 14 percentage points higher. This indicates that the F/A-18 program did not do better than non-DTC programs.

The following observations can be made about the F/A-18 experience:

- The contractor saw the Navy as being unwilling to trade other system parameters, e.g., performance for cost.
- Design, performance, and cost interrelationships were not established during the program conception phase to allow cost-reducing design tradeoffs.

Table 1. F-A/18 Schedule and Cost Outcomes Versus All Tactical Aircraft Outcomes

| | F/A-18 | All Tactical Aircraft |
|---|---|---|
| Development Cost Growth | 1.15 | 1.18 |
| Development Schedule Growth | 1.08 | 1.03 |
| Development Quantity Growth | 1.00 | 1.10 |
| Production Cost Growth | 1.42 | 1.25 |
| Production Schedule Growth | 1.71 | 2.12 |
| Production Quantity Growth | 1.45 | 1.65 |
| Total Program Cost Growth | 1.37 | 1.23 |

- The original DTC goal was not continually updated and tracked through changes in design, performance, production quantity, and schedule.
- Parametric cost estimates often vary widely from actual costs, yet parametric cost estimates were not updated to reflect actual costs as the data became available. This practice would permit an accurate and timely assessment of DTC program effectiveness.
- The contractor saw the Navy as placing insufficient emphasis on DTC.
- The Navy saw the contractor as appearing to make a sincere effort to implement the DTC program, but failing to follow it through.

<u>A-10 Aircraft</u>

In December 1970, development contracts for A-9 and A-10 prototypes were awarded respectively to Northrop Corporation and Fairchild Republic Division, Fairchild Industries. The firm-fixed-price contracts, void of the usual military specifications, standards, and other normal procurement requirements, provided the contractors with maximum flexibility to trade performance and cost. In March 1973, following the competitive Air Force flight evaluation of the full scale development and production proposals, contracts were awarded to Fairchild Republic and General Electric as the airframe and engine contractors, respectively. Fairchild Republic's contract was a cost-plus-incentive-fee (CPIF) contract to build ten (cut to six by Congress in 1974) pre-production aircraft on a negotiated schedule. The incentive was for cost reduction alone, not for increasing performance.

The main DTC clause defined unit production flyaway costs as the sum of all recurring and non-recurring costs (excluding all RDT&E costs) necessary to produce a complete aircraft, including the applicable portion of system engineering and program management. A prime objective during full scale development was to design to cumulative average unit production flyaway cost of $1.5 million in FY 1970 dollars for a total of 600 aircraft at a maximum rate of 20 aircraft per month.

The DTC objective was the requirement stated in the initial RFP. The competing contractors were provided the latitude to make tradeoff studies to achieve maximum system performance while meeting the DTC objective.

The contractor was held responsible for controlling and tracking its portions of the costs and for reporting any cost changes over $3,000 on the Monthly Cost Performance Report in both current and FY 1970 dollars. Also, any proposed actions or tradeoffs to bring the costs back within the limit had to be reported. The uncertainty of inflation did not affect the cost goal because it was expressed in constant dollars. The costs applicable to the DTC goals were separately collected, recorded, and reported. The Total System Integration Responsibility clause made Fairchild responsible for ensuring that the entire system cost remained within the $1.5 million cost goal. Failure on the part of Fairchild to meet the DTC goal in any of the areas discussed could result in possible contract termination [5].

Noteworthy features of Fairchild's implementation of DTC are:

- The way the company organized the design team
- The emphasis placed on applying more money in the prototype phase to produce a "production similar" prototype aircraft
- The selection of a high-thrust engine already developed, the extensive use of trade studies, and the use of an iteration process with the engine manufacturer to reduce engine costs.

According to Fairchild, the A-10 design tradeoffs and lessons learned during the prototype development allowed for a significant reduction in production costs, which permitted the Air Force to minimize its spare parts inventory. Table 2 shows the A-10 schedule and cost outcomes.

Compared with all tactical aircraft in our study, the A-10 total program cost growth is 10 percentage points higher. This indicates that the A-10 program did not do better than non-DTC programs. However, the A-10 System Program Office paper [6] defended the program's success by stating that the DTC concept should not be used only as a mechanical, numerical tracking system: "We don't know how much it saved, but are convinced, without any reservations, that the A-10 aircraft is a significantly less expensive system today than it would have been without the application of the DTC concept."

The following observations about the A-10's DTC program may have contributed to the program's success:

- Achievable goals were established early in the program conception phase.
- Aircraft requirements were realistically set.
- Through necessary tradeoffs, acceptable performance was provided within a price the government could afford to pay.
- Contractors, managers, and engineers were kept informed.

<u>AH-64 Helicopter</u>

The AH-64 program had DTC tracking from its outset. The program commenced with a design-to-unit-production-cost goal of $1.4 million to $1.6 million in FY 1972 dollars that was later changed to a unit flyaway cost of $1.8 million in FY 1972 dollars. Due to additions to DTC goals to reflect definitive changes in DoD Instruction 5000.33 for flyaway costs--the impact of changes in mission equipment to include the Hellfire missile and the Target Acquisition Designation Sight/Pilot Night Vision Sensor (TADS/PNVS) subsystems, adoption of the Armament Development Enfield/Direction D'Etudes et Fabrication D'Armament (ADEN/DEFA) 30mm rounds area weapon subsystem, and changes in GFE-- the DTC goal grew to $3.05 million in FY 1972 dollars by FY 1987 [7].

Table 2. A-10 Schedule and Cost Outcomes Versus All Tactical Aircraft Outcomes

| | A-10 | All Tactical Aircraft (8) |
|---|---|---|
| Development Cost Growth | 1.27 | 1.18 |
| Development Schedule Growth | 1.08 | 1.03 |
| Development Quantity Growth | 0.71 | 1.10 |
| Production Cost Growth | 1.34 | 1.25 |
| Production Schedule Growth | 0.98 | 2.12 |
| Production Quantity Growth | 1.00 | 1.65 |
| Total Program Cost Growth | 1.33 | 1.23 |

Table 3 presents our analysis of the AH-64 program cost and schedule outcomes versus all helicopter programs in our database. As presented, the AH-64 total program cost growth is 20 percent higher than all helicopter programs in our study.

Among the findings from the AH-64A acquisition management practices are the following:

- DTC did not serve to discipline cost growth, especially for non-recurring tooling, engineering, and program management service costs.
- DTC was not fully executed. DoD did not have enough manpower to conduct the in-depth analysis required.

Two lessons can be learned from the AH-64A DTC application:

- A DTC program may not serve to discipline cost growth.
- A prototype during engineering development (or advanced development) is necessary.

## ANALYSIS OF TOTAL SAMPLE

Of the 63 major programs in our study, 27 programs have DTC application. Table 4 presents a comparison of the average total cost growth between the DTC programs and the non-DTC programs for the programs.

As shown, the overall cost growth in DTC programs is 19 percentage points greater than that of the non-DTC programs. Overall statistics of the 89-program sample in our study indicate that the DTC concept has not been effective as presently practiced.

However, the analysis of cost and schedule outcomes of DTC versus non-DTC programs by time period (late 1960's, early 1970's, late 1970's, early 1980's) indicates that DTC programs were successful in the late 1970s. In that period the cost growth of the DTC programs is only 48 percent and that of the non-DTC programs is 83 percent [8]. It may be that, by the late 1970s, the DTC concept had had enough time to become established and to be applied early enough in a program to be effective. A summary of cost and schedule growth by time period is presented in Table 5, and illustrated in Figure 2.

A case-by-case analysis indicates that the typical method of implementing DTC on the acquisition of major weapon systems have substantially reduced its potential effectiveness. The primary reasons for this are:

- Most systems we had information on had the DTC requirements forced upon them as a retrofit, after initial R&D contracts were awarded. Because of this retrofitting, it is difficult to evaluate the effectiveness of DTC.
- System performance is still the first priority. Traditional emphasis on performance and schedule resulted in a relatively low priority being given to cost.
- DTC has been used mainly as a cost-monitoring device in FSD rather than as a tool for making tradeoffs earlier in the process.
- Use of data and feedback on DTC has not been sufficient to encourage contractor emphasis on DTC programs.
- There has been an absence of continued technical evaluation of design/effectiveness/cost trade-off throughout the program acquisition phase.

Table 3. AH-64 Schedule and Cost Outcomes Versus All Helicopter Outcomes

| | AH-64 | Helicopters (5) |
|---|---|---|
| Development Cost Growth | 1.26 | 1.36 |
| Development Schedule Growth | 1.49 | 1.16 |
| Development Quantity Growth | 1.00 | 0.93 |
| Production Cost Growth | 1.74 | 1.46 |
| Production Schedule Growth | 0.83 | 1.01 |
| Production Quantity Growth | 1.26 | 0.95 |
| Total Program Cost Growth | 1.59 | 1.39 |

Table 4. Summary of Cost and Schedule Outcomes of DTC Versus Non-DTC Programs

| | DTC | Number of Programs | Non-DTC | Number of Programs |
|---|---|---|---|---|
| Development Cost Growth | 1.32 | 32 | 1.25 | 48 |
| Development Schedule Growth | 1.43 | 32 | 1.28 | 49 |
| Development Quantity Growth | 1.05 | 32 | 1.17 | 44 |
| Production Cost Growth | 1.78 | 27 | 1.57 | 36 |
| Production Schedule Growth | 1.67 | 27 | 1.64 | 30 |
| Production Quantity Growth | 1.20 | 27 | 1.24 | 36 |
| Total Program Cost Growth | 1.63 | 27 | 1.44 | 36 |

Note: Figures are dollar-weighted.

Table 5. Summary of Cost and Schedule Outcomes of DTC Versus Non-DTC Programs by Time Period

| Time Period | No. of Programs | DCG | DSG | DQG | No. of Programs | PCG | PSG | PQG | TPCG |
|---|---|---|---|---|---|---|---|---|---|
| Late 1960s | | | | | | | | | |
| DTC | 1 | 1.72 | 3.00 | 1.19 | 1 | 6.61 | 1.12 | 0.02 | 5.19 |
| Non-DTC | 21 | 1.36 | 1.38 | 1.17 (19) | 20 | 1.64 | 1.67 (17) | 1.05 | 1.50 |
| All | 22 | 1.36 | 1.46 | 1.17 (20) | 21 | 1.89 | 1.64 (18) | 1.00 | 1.66 |
| Early 1970s | | | | | | | | | |
| DTC | 5 | 1.40 | 1.42 | 1.42 | 5 | 1.60 | 1.76 | 0.92 | 1.53 |
| Non-DTC | 7 | 1.20 | 1.11 | 1.26 | 6 | 1.18 | 1.94 (4) | 1.34 | 1.18 |
| All | 12 | 1.25 | 1.24 | 1.33 | 11 | 1.42 | 1.84 (9) | 1.15 | 1.37 |
| Late 1970s | | | | | | | | | |
| DTC | 21 | 1.29 | 1.40 | 0.96 | 19 | 1.55 | 1.73 | 1.40 | 1.48 |
| Non-DTC | 9 | 1.26 | 1.30 | 1.14 | 7 | 2.17 | 1.59 | 1.78 | 1.83 |
| All | 30 | 1.28 | 1.37 | 1.01 | 26 | 1.73 | 1.69 | 1.50 | 1.59 |
| Early 1980s | | | | | | | | | |
| DTC | 5 | 1.25 | 1.26 | 1.03 | 2 | 0.92 | 1.15 | 0.58 | 0.93 |
| Non-DTC | 11 | 1.13 | 1.19 (12) | 1.13 (9) | 3 | 0.91 | 1.00 (2) | 1.02 | 0.91 |
| All | 16 | 1.16 | 1.21 (17) | 1.09 (14) | 5 | 0.91 | 1.07 (4) | 0.85 | 0.92 |

Note: Figures are dollar-weighted.

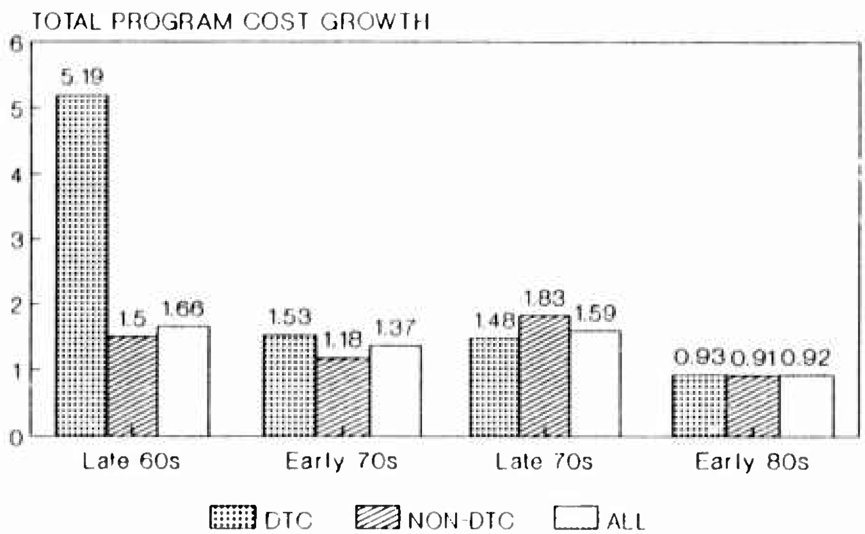


Figure 2. Total Program Cost Growth of DTC Versus Non-DTC Programs by Time Period

- There has been no standardized method to implement DTC. Each DTC program uses its own management approach and definition. For example:

  -The A-10 program introduced a 10-year life-cycle-cost requirement, but the emphasis was on meeting the stringent unit production cost goal for continued support.

  -The Utility Tactical Transport Aircraft System (UTTAS) program placed contractual DTC goals and incentives on average airframe production cost.

  -The contractor's cost model for the CH-47 modification program did not include the impact of tradeoffs in achieving DTC unit production goals on operation and support costs.

  -The F/A-18's DTC value was based on a cumulative average recurring cost for 800 aircraft.

  -The AH-64A's DTC cost goal was based on the production cost for the A-10 airframe.

Generally, DTC targets (affordability limits) were not established during concept formulation, when the greatest flexibility existed to maximize total performance for the dollars available (UTTAS and CH-47 modification) [9].

DTC has the potential to produce significant cost reductions beyond those achieved if problems experienced could be resolved. However, most DTC programs have been given lip service only.

## GUIDELINES FOR SUCCESSFUL USE OF DTC

The following are guidelines for successful use of DTC:

- Early DTC goal establishment. The goal must be established before the start of the validation phase, because it provides a baseline to work against in the tradeoff decisions, which occur during validation.
- Design flexibility. The number of specified performance para- meters should be minimized in DTC. They should also be ranked according to priority, if possible.
- Use of new technology to lower cost rather than to increase performance. This requires a change on the part of engineers who for years have been encouraged to rank performance over cost.

  Cost estimating. The DTC goal should be allocated down the work breakdown structure and tracked regularly for both prime contractor and subcontractor efforts. The DTC goal should be related to quantity from Unit 1 on up; setting a DTC goal for Unit 1 imposes strict discipline on the designer and permits an early indication of compliance.
- Contractual incentives. Contractual innovations are needed to give the contractor an incentive to build a reliable, low-cost product. Reliability Improvement Warranties and award fees are two such devices.
- Availability of time and money. DTC should require that adequate time and sufficient funds are available during development to permit examination of tradeoffs and alternative design approaches. Constraining either may cause sub optimization.
- Realistic cost objectives. The goal should reflect the best estimate based on available data.
- Constant-year-dollar cost goals. Expressing the cost goals in constant-year dollars provides a baseline to measure costs against, even with inflation affecting the value of future-year dollars.

## CONCLUSIONS

DTC has not been effective as practiced. Most DTC programs applied DTC either as a retrofit or too late in the development phase (full scale development) to be cost-effective. As our macro-analysis of the database indicates, cost growth is greater for DTC programs than for non-DTC programs, except in the late 1970s. This exception may be because the DTC concept had become well enough established by the late 1970s to be implemented earlier in the programs.

However, DTC can work if applied properly. To be cost-effective, DTC should be implemented early in the conception phase where design tradeoffs are still feasible. It is important that the DTC goal be established as early as possible in the development cycle, because it is the early design decisions that will have the most effect on cost.

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## EVOLUTIONARY ACQUISITION IN JOINT ACQUISITION?

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ABSTRACT

Command and control systems acquisition remains a difficult area. In joint acquisition programs for command and control systems, without a bona fide mechanism for insuring the commitment of the large numbers of disparate players, novel approaches such as an evolutionary acquisition strategy only introduce risk into the program, complexity into the organizations and their procedures, and as a result, destabilize these joint acquisition programs. As this paper shows, joint acquisition programs cannot afford that. Rather, they have to resolve up front requirements, cost, schedule, funding, and organization. The conclusions of this paper address the need for policy applicable both to an evolutionary acquisition strategy and to a joint acquisition program to consider the attributes of each other, and if need be, to consider the mechanisms necessary to implement each in conjunction with the other.

### INTRODUCTION

The policies of the Office of the Secretary of Defense and of the Joint Logistics Commanders support the use of an evolutionary acquisition strategy in acquiring command and control systems. At the same time, these policies note that the unique circumstances of individual programs should be considered. This paper examines the unique circumstances of joint acquisition programs and relates these circumstances to the evolutionary acquisition of command and control systems.

Why is this important? According to the President's Blue Ribbon Commission on Defense Management -- the Packard Commission -- "Chances for meaningful improvement [in the defense acquisition system] will come not from more regulation but only with major institutional change." The use of an evolutionary acquisition strategy represents such an institutional change in the traditional acquisition process (albeit not a "major" change). Whether use of such a strategy provides for meaningful improvement in joint acquisition programs so as to lead to successful programs is the thrust of this paper.

### Evolutionary Acquisition

Problems in command and control systems acquisition are not new. Since the early 1960s, few participants in the process remain satisfied with the results of efforts to field, within a reasonable period of time, operationally effective systems. According to Mr. Robert B. Doane in the Autumn 1982 issue of Concepts, the principal reasons for the poor record of command and control systems acquisition stem: (i) from the lack of ability on the part of the operational command to state system needs consistent with the rapidly evolving potential provided by the computer explosion; and (ii) from unforeseen weaknesses in the classic weapon system acquisition process when it was applied to command and control systems acquisition.

Evolutionary acquisition is an alternative strategy which may be used in command and control systems acquisition. The Department of Defense currently has two policy statements on evolutionary acquisition. The first statement is in Defense Acquisition Circular #76-43 (22 March 1983), issued by the Office of the Secretary of Defense and referenced in DOD Directive 5000.2 (1 September 1987). Quite similar is the second statement in the Joint Logistics Commanders Guidance for the Use of an Evolutionary Acquisition (EA) Strategy in Acquiring Command and Control (C2) Systems (March 1987). It states:

Evolutionary acquisition is an acquisition strategy which may be used to procure a system expected to evolve during development within an approved architectural framework to achieve an overall system capability. An underlying factor in evolutionary acquisition is the need to field a well-defined core capability quickly in response to a validated requirement, while planning through an incremental upgrade program to eventually enhance the system to provide the overall system capability. These increments are treated as individual acquisitions, with their scope and content being the result of both continuous feedback from developing and independent testing agencies and the user (operating forces), supporting organizations, and the desired application of new technology balanced against the constraints of time, requirements, and cost.

The September 1982 Command & Control Systems Acquisition Study Final Report by the Armed Forces Communications and Electronics Association proposes the following benefits accrue to the Department of Defense from the use of an evolutionary acquisition strategy to acquire command and control systems:

- A measurably increased command and control capability in the hands of users, achieved far sooner than if DOD waited for a one-time "total" solution, due to the incremental, user-oriented development approach.
- Greater user satisfaction with, and more rapid assimilation of, systems resulting from the evolutionary command and control system acquisition process, as a result of the user's close and continuous coupling with the acquisition, and the smaller, more-frequently-fielded increments that the user will receive.
- Reduced government risk and exposure, since each increment is limited.
- Easier technology insertion, and hence reduced obsolescence of materiel in the field, due to an architecture and approach to design aimed at readily accommodating change.
- Longer useful life of command and control systems, also resulting from an architecture that readily accommodates change.

Despite those benefits, there are only a few acquisition programs known to use an evolutionary acquisition strategy. They include elements of Worldwide Military Command and Control System (WWMCCS) like the WWMCCS Information System and like the upgraded systems for the North American Aerospace Defense Command.

Joint Acquisition

Because of technology, operational considerations, and budget constraints, there is a great emphasis on joint acquisition programs for command and control systems. Although there are problems with joint acquisition programs, Mr. Donald C. Latham (in 1984, the Deputy Under Secretary of Defense (C3I)) poses rhetorically:

> With such evident dysfunctions in joint acquisitions, one may logically ask, why have joint C3I programs at all? That logical question has an equally obvious answer -- we have them because we simply do not operate or fight as a single service anymore -- a fact of life many still find difficult to swallow. Also, interoperability and cost effectiveness demand that we combine resources and system requirements in joint acquisitions.

In the decade ending in 1984, statistics show joint programs increasing from 20 percent of major programs to 25 percent of major programs. And about 65 percent of DOD's command and control programs are joint acquisitions (circa 1984). As stated in the Joint Logistics Commanders' 1984 Joint Program Study Final Report, there are three fundamental trends which increase pressure for joint service development and procurement programs: (i) doctrinal emphasis on joint warfighting and interoperability of forces; (ii) deployment of emerging technologies permitting integration of multiservice command and control systems and force structures; and (iii) Congressional demands for greater cost-effectiveness in military procurement.

According to the Defense Science Board 1983 summer study on joint service acquisition, about two-thirds of the joint acquisition programs are "successes" or have good prospects for success. Relative to command and control systems, however, as long as the critically-important abilities to interoperate and intercommunicate are preserved, a program need not be joint to be successful.

In order for joint acquisition programs to obtain operational or economic advantages, the Joint Logistics Commanders' Guide for the Management of Joint Service Programs emphasizes two points. First, joint acquisition programs need to insure that the technical, organizational, and funding bases exist between the participating services and agencies; and second, joint acquisition programs have to resolve the operational and technical requirements issues at the beginning. The Joint Requirements Oversight Council, for example, endorses such a concept based on a preferred funding arrangement for joint programs in which programs falling under this concept must have a firm statement of requirements and a detailed agreement covering technical baselines.

## INHERENT CONFLICTS

In the May, 1983, issue of Signal, Lieutenant General Robert Herres (in 1983, Director, Command, Control, and Communications Systems Directorate, Organization of the Joint Chiefs of Staff; now, the current JCS Vice Chairman) states:

> I have since found that the problem with the evolutionary acquisition concept is that the term is easy to use, but it is hard to implement. What are we going to do, or have we done, to the acquisition process to accommodate that, i.e., to the rules that guide the day to day realities of program management? The point is that there has been more talk about the evolutionary approach, which I enthusiastically support, than there has been about what one does with the various directives and procurement regulations.

Ironically, one of the very few attempts to date to focus on what Lt. Gen. Herres calls "the day to day realities of program management" occurs in the same Signal issue. In another article in that issue, Dr. Norman Waks (in 1983, the Chief Management Scientist of MITRE Corporation) addresses some of the outstanding issues not covered in the Armed Forces Communications and Electronics Association (AFCEA) study team's 1982 Command & Control (C2) Systems Acquisition Study Final Report. He supplements the AFCEA report by describing briefly some of the more basic conflicts inherent in using an evolutionary acquisition strategy for command and control systems acquisition.

Dr. Waks lists these several conflicts as inhibitors to program success: (i) introducing new technology; (ii) increasing user influence; (iii) defining system requirements; (iv) competing funding interests; (v) developing appropriate requirements; (vi) managing system integration; (vii) allowing commander flexibility; (viii) implementing special management procedures; and (ix) using alternative acquisition strategies.

To gain an understanding of some of the difficulties in using an evolutionary acquisition strategy in joint acquisition programs for command and control systems, the rest of this section looks the first five inherent conflicts on Dr. Waks's list.

### New Technology

Introducing new technology in an evolutionary manner has risks for the developer in joint acquisition programs. For example, the Defense Science Board 1985 summer study on practical functional performance requirements supports use of block upgrades, somewhat akin to evolutionary acquisition. Similarly, the Defense Science Board 1983 summer study on joint service acquisition programs endorses a series of evolutionary, "learn-by-doing", technology demonstrations, with strong user involvement.

Despite the apparent recognition of the value of an evolutionary approach, both Defense Science Board reports find otherwise. The 1985 Defense Science Board summer study finds that successful programs either have the required technologies in hand before development or have the relevant risks identified, recognized, and programmed through schedule and resources (people, money, things, information). This is not typical in an evolutionary acquisition approach.

Similarly, while there have been many successful joint programs, the 1983 Defense Science Board summer study concludes that most successes occur in non-major systems, subsystems, components, and technology base programs. These kinds of successful joint programs are not the kinds of programs common in command and control systems acquisition.

### User Influence

This is an organizational problem of concern when using an evolutionary acquisition strategy, since prior user experience with command and control systems impacts on the development effort, in particular for joint users. But joint users tend not to have the sophistication and understanding of their unique systems compared to their counterparts in the services. The result is that the military departments, serving as the acquisition executives, focus their attention and funds on their own command and control needs.

For example, when the users happen to be the unified commands, there are three areas of specific concern, according to a 1980 Joint Logistics Commanders memorandum, regarding experience necessary for more participation in command and control systems management. The first is configuration management and life cycle support responsibilities -- do the users have the funds necessary to effectively fulfill their responsibilities in those areas? The second is technical personnel -- is the use of a cadre of systems engineering personnel appropriate for an operational command? The third is duplication of effort -- if the systems engineering efforts of the unified commands are not coordinated with the service acquisition commands, will there be needless duplication of effort? Indeed, the 1985 Defense Science Board summer study on practical functional performance requirements singles out the unified commands' widely varying responsibilities, missions, and staffing as contributing to acquisition problems characterized by inadequate resources, overstated performance goals, and concealed risks.

On the other hand, for users who are not joint, but the program is for reasons of compatibility and interoperability, Dr. James Wade (in 1985, the Assistant Secretary of Defense for Acquisition and Logistics) reports the individuals, serving as the "joint" users, seem to focus their attention and time on interservice rivalries that hinder joint planning and acquisition, as well as hinder the optimal use of new technology.

Command and Control System Requirements

Defining system requirements offers some frustration to the developer according to Dr. Waks: how can life cycle costs be accommodated with sound programmatic decisions since in this "core" dependent approach, requirements are so difficult to describe? Indeed, an evolutionary acquisition strategy needs complete information to evaluate the current increment, as well as to identify, concurrently, areas where additional improvement is required.

For joint acquisition programs, defining command and control systems reqirements is just as difficult. As Admiral William J. Crowe, Jr. (current JCS Chairman), writes, "Perhaps the overarching challenge is best understood as one of adequately identifying requirements." Similarly, joint acquisition program requirements are "The Number One Problem" according the Comptroller General, who cites different perceptions of requirements, doctrines, and operational features, but especially doctrinal requirements. Subsequent to the Comptroller General's 1983 report, the Defense Science Board 1983 summer study on joint service acquisition programs also attributes problems in joint programs most often to the failure of the services to agree on requirements.

But on the other hand, requirements which satisfy everyone drive up program expenses; and the coordination process associated with joint programs just requires more time. Thus, users, who originally wanted the system, attempt to shift to service unique programs or to eliminate the requirement altogether.

Competition for Funds

From the developer's perspective according to Dr. Waks, is the program using an evolutionary acquisition strategy repeatedly exposed to a competition for funds? For a number of reasons, that is not good for a joint program.

First, according to the Joint Logistics Commanders' Joint Program Study Final Report, rates for average cost and schedule growth for joint programs already are significantly higher than similar rates for single service programs. The report's statistical analysis shows that the factors most closely associated with those higher rates are problems in resolving performance requirements and turbulence in funding. Second, those factors increase development time and, as a result, increase vulnerability to program changes and inflation. For command and control systems, an evolutionary acquisition strategy consequently exposes the program to more of these systemmatic fluctuations; a joint acquisition program merely compounds the problem.

Third, those factors (problems in resolving performance requirements and turbulence in funding), too, serve to undermine support within the military departments. Often, as the Defense Science Board 1983 summer study on joint service acquisition programs finds, major problems accrue to the joint program when one service reduces its funding due to changing priorities, an issue that largely disappears for single-service funded joint programs. As Mr. Donald C. Latham (in 1984, the Deputy Under Secretary of Defense (C3I)) writes,

> Part of this problem is the nature of the planning, programming and budgeting process within the Department. Each Military Department will naturally value the internal programs which satisfy its own mission requirements higher than the joint programs in which it participates. Thus when prioritization actions must be taken to reduce resource allocations, the joint programs suffer disproportionately.

In the end repeated exposure to a competition for funds has a detrimental effect. In Military Systems Acquisition in the NATO Market, Mr. Kelly Campbell (in 1985, former US Representative to the NATO Infrastructure Committee) illustrates wnat can happen when an evolutionary acquisition strategy is used for joint program acquisition (albeit in a multinatinal environment).

> NATO C3I projects fall into essentially two groups -- new departures and replacement/upgrading. Group One projects will usually be more complex and therefore centrally-managed [for example, the NATO Integrated Communications System (NICS) or the NATO Air Command and Control System (ACCS)]. Since Group Two projects start from known technology and are less complex, they can be decentralized to individual host nations [for example, the NATO Air Defense Ground Environment (NADGE) Upgrade]. This distinction can be important because host nations do not always buy to standard specifications....
>
> Complex, expensive and current, the ACCS [Air Command and Control System] gives some indications of [the impact of an acquisition strategy to a Group One project]...[T]he long-term design for the ACCS must marry the use of emerging technology with shorter term need and budgetary limitations. It was considered that this could best be done by following an evolutionary approach instead of the kind of "turn-key" project represented by the NADGE and other systems of that generation....
>
> [But, use of an evolutionary approach to acquire the ACCS has not lead to a

successful acquisition program.] It is impossible to ignore the disadvantages of the pattern we observe here, that is, careful preliminary study and preparation and an evolutionary approach to the acquisition of systems. Given rapidly escalating costs, particularly in the C3I area, this will make it more difficult to bring to fruition the longer-term elements of the ACCS plan. The alternative obviously is to attempt to design a total system and to install it in as short a period of time as possible. This was the approach taken in Phase One of the NATO Integrated Communications System [(NICS)], and, in spite of all the problems which have been described elsewhere...the elements of NICS One will be substantially operational within the next two or three years. At the same time, the evolutionary idea which was embodied in NICS Phase Two has fallen by the wayside, due almost entirely to concerns about cost escalation and competing military priorities.

Requirements Process

With respect to evolutionary acquisition of command and control systems, there is the need for requirements to be as dynamic as possible so that user needs evolve on the basis of a feedback driven "design-and-try-out" philosophy; but, there is also a need for requirements to be as stable as possible so that the command and control capability needed by the user will be satisfied. Nevertheless, even though an evolutionary acquisition strategy has an inherent conflict in the management of change, the change process has some degree of formal structure. Unfortunately, the joint requirements process does not.

The JCS requirement validation process, for example, is time consuming, even though the capability being sought is clearly needed, technically feasible, and not necessarily very costly. According to Mr. Donald C. Latham (in 1987, the Assistant Secretary of Defense (C3I)), "this time lag is a basic flaw in the acquisition process."

The joint requirements process also has little relation to its resourcing. Even if the requirement were validated by the Joint Chiefs of Staff, resource support is not automatic. The service or agency responsible must program and budget for the requirement in its Program Objective Memorandum. If the service or agency does not, this becomes an issue; and these issues usually fall below the threshold for high-level attention in the Defense Resources Board.

## HOW TO DECIDE?

Given the discussion above on inherent conflicts in using an evolutionary acquisition strategy in joint acquisition programs for command and control systems, how does one decide whether to use such a strategy or not? Sets of criteria exist to determine when an evolutionary acquisition strategy is appropriate to use and when an acquisition program is a viable joint candidate. The following discusses the interaction of each with each other and introduces what the Packard Commission thinks.

Evolutionary Acquisition Criteria

The Armed Forces Communications and Electronics Association's Command & Control (C2) Systems Acquisition Study Final Report (September 1982) establishes a number of criteria stipulating when command and control systems shall be acquired in an evolutionary manner. These criteria are:

- The requirements are not definite.
- The user is not satisfied with the completeness of the requirements specification.
- Requirement changes are expected to be rapid or extensive during the useful life of the system.
- The user can not specify acceptance (quantitative operational utility) criteria for the system which others can be expected to apply objectively to measure operational mission performance.
- The user's role can not be minor during development.
- There is not an insignificant amount (relative to total program size) of man/machine interfaces and new software development involved in the program, the latter of a type which is highly interactive with the decision process.

Packard Commission Criteria

The President's Blue Ribbon Commission on Defense Management (June 1986) -- the Packard Commission -- reveals that there are certain characteristics common to successful government projects (and to successful commercial projects as well). In particular, an evolutionary acquisition strategy's emphasis on building and testing prototype systems, on beginning operational testing early, and on communicating with users represents a collection of features which the Packard Commission found typical of the most successful commercial programs. So, in comparing the Packard Commission's recommendations relative to an acquisition strategy, evolutionary acquisition of command and control systems supports, to some extent, those recommendations.

But there the similarity stops; for the Packard Commission's fundamental criterion for success in program acquisition, including command and control systems acquisition, is "An informed trade-off between user requirements, on the one hand, and schedule and cost, on the other." The Packard Commission indicates that this informed trade-off is achieved through a balance of cost and performance:

> A delicate balance is required in formulating system specifications that allow for a real advance in military capability but avoid goldplating. Generally, users do not have sufficient technical knowledge and program experience, and acquisition teams do not have sufficient experience with or insight into operational problems, to strike this critical balance. It requires a blend of diverse backgrounds and perspectives that, because the pressures for goldplating can be so great, must be achieved at a very high level in DoD.

Quite clearly, the criteria for an evolutionary acquisition strategy do not focus on the informed trade-off important to the Packard Commission, but on an informed trade-off between requirements. Joint acquisition programs compare differently relative to the Packard Commission's criterion -- an informed trade-off between user requirements, on the one hand, and schedule and cost, on the other.

Joint Acquisition Criteria

The Joint Logistics Commanders' Joint Program Study Final Report (July 1984) establishes a number of criteria stipulating when an acquisition program shall be acquired as a joint acquisition program. These criteria are:

- Is the end item clearly single service?
- Net cost benefit? and/or
- Joint warfighting/interoperability benefit?
- Can the requirements be resolved?
- Is there a basis for commitment?

Despite guidance from the Joint Logistics Commanders that nothing is more important to the success of a joint program than inter-service agreement on requirements and funding (commitment), the services quite often disagree. Consequently, the need to pin down requirements and funding to execute joint programs seems at cross purposes with an evolutionary acquisition strategy in which the full capability does not occur when initially deployed, but occurs in increments over time.

Discussion

Even given that evolutionary acquisition is oriented on only those few characteristics that distinguish command and control systems, the Packard Commission's criterion clearly emphasizes the importance of cost and schedule regardless of the type of system. In contrast, evolutionary acquisition significantly reflects the role of requirements. What becomes quite obvious in addressing the bottom line of cost and schedule is the relatively little information available on that point (with respect to use of an evolutionary acquisition strategy) considering the importance of cost and schedule as established by the Packard Commission.

The criteria for joint acquisition programs, on the other hand, remain relatively consistent with the criterion established by the Packard Commission. The criteria for joint acquisition programs, however, remain somewhat inconsistent with analogous criteria for evolutionary acquisition. In fact, the only real overlap is in requirements; but with respect to that overlap, there is a disconnect between the two criteria. For joint acquisition programs to be successful, requirements must be resolved; for use of an evolutionary acquisition strategy, requirements are not definite -- therefore, they are not resolved.

Even given that evolutionary acquisition does not attempt to deal with problems common to all acquisition programs, the crux of the choice in determining whether to use an evolutionary acquisition strategy rests on an indefinite state of requirements. There is, too, some concern about commitment, since the user basically is not satisfied with the completeness of the requirements specification. Consequently, there exists little basis for an informed tradeoff if the requirements cannot be made more definitive; for rapid, extensive requirements changes deter joint service commitment since the changes look like a blank check to goldplate.

Quite the opposite occurs with a decision to support a joint acquisition program. For a successful joint acquisition program the requirements must be resolved; there must be a firm basis for commitment; and there must be a net cost benefit. At this point applying the Packard Commission's criterion shows little agreement in supporting a decision to use an evolutionary acquisition strategy in a joint acquisition program. No tradeoff can really occur when the user hedges on commitment, when the requirements remain relatively undefined, or when an estimate cannot be made as to ultimate cost. The basis for a successful program does not exist.

Further, in some respects even what leads to "program success" differs conceptually between evolutionary acquisition and joint acquisition. The introduction of new technology is one example. Without new technology in hand, the success rate for joint acquisition programs is not there. That is a basic incompatibility with using an evolutionary acquisition strategy, which anticipates forthcoming, not-yet-in-hand technology. The perspective on time is another example. The nature of an evolutionary acquisition strategy is inherently to stretch the schedule; the nature of a joint acquisition program is inherently to fight any schedule stretches to retain program advocacy.

Additionally, the criteria for an evolutionary acquisition approach do not anticipate the three hallmarks for program success -- cost, schedule, performance -- just performance. Somehow within the context of a single service, cost and schedule adjustments occur with controllable ripples. That is not true for a joint acquisition program. For the opposite example, the criteria for a joint acquisition approach do not anticipate fully command and control systems' unique characteristics like requiring some user involvement. Somehow, too, within the context of a single service, performance adjustments (during command and control systems acquisition) occur through controllable iterations with the user. Due to cost and schedule constraints imposed by the services in a joint acquisition program, that is not true for an evolutionary acquisition approach.

Thus, both an evolutionary acquisition strategy and a joint acquisition program have criteria to be used to decide whether to implement such a "strategy" or to establish such a "program." Each remains appropriate within its own context, but not necessarily so when the context changes (as using an evolutionary acquisition strategy on a joint acquisition program, or as executing a joint acquisition program for command and control systems).

Is that a sufficient basis to determine the suitability of using an evolutionary acquisition strategy in joint acquisition programs for command and control systems?

The earlier discussion above on the inherent conflicts with an evolutionary acquisition strategy as applied to joint acquisition programs substantially reinforces the Packard Commission's criterion. Introducing new technology, for example, has inherent risks to the developer. Joint acquisition program successes seem to occur at the subsystem, component, and technology base level rather than at the system level, where the focus exists for an evolutionary acquisition strategy for command and control "systems." A forte of evolutionary acquisition is the system-level introduction of new technology -- yet, constant introduction of new technology at the system level leads to unsuccessful joint acquisition programs. Hence, there is an absolute need to tradeoff to couple favorable evolutionary acquisition features (like prototyping and testing, and communications with users) with analogous features associated with successful joint acquisition programs (like program stability).

Finally, the policies relative to evolutionary acquisition and the policies relative to joint acquisition must consider the effects of each. That is, any evolutionary acquisition policy must consider the unique challenges faced by a joint acquisition program; and the corollary -- any joint acquisition policy affecting command and control systems must consider the special attributes of these systems.

For example, current evolutionary acquisition policy, represented by the Joint Logistics Commanders Guidance for the Use of an Evolutionary Acquisition (EA) Strategy in Acquiring Command and Control (C2) Systems, does not consider the unique challenges of joint acquisition programs. Two of the big problems in the execution of joint programs involve maintaining program stability and harmonizing service business practices. Yet, the policy on use of an evolutionary acquisition strategy ignores recommended solutions to each, like standardizing business practices and baselining (a technique used to enhance stability and control cost growth). Indeed, baselining seems to counteract an evolutionary acquisition policy; ergo, any evolutionary acquisition strategy policy must address this seeming incompatibility. Similarly, the demands of an evolutionary acquisition policy for modifications to the normal way of doing business run counter to standardizing practices between the services. So, any evolutionary acquisition strategy policy must address what the services should do in joint acquisition programs (even as this paper concludes, to avoid the joint acquisition programs).

On the other hand, any policies developed to address joint acquisition programs, represented here, for instance, by the Joint Logistics Commanders' Guide for the Management of Joint Service Programs, must consider the special attributes of command and control systems. The principal illustration is the disconnect between the way requirements are developed for command and control systems verses other weapons systems. The continuous, and changing, nature of these requirements means a continuous, and changing, problem for any joint acquisition program and for any functionally related organization (logistics agencies, test agencies, etc.). For example, the joint command and controls systems environment has organizations like the Joint Tactical Command, Control, and Communications Agency in the tactical arena or the Systems Integration Office in the strategic arena which together complicate the classic test structure. Current joint acquisition guides remain silent on the effect of these added participants. Another example is the development-like process verses production-line process inherent in command and control systems verses other weapons systems. Joint acquisition program procedures remain inadequate to deal with such command and control system facts-of-life. Again, another illustration is that the development-like characteristics of command and control systems include the role of architecture and standards, which shift the focus for any joint acquisition program if systems can interoperate through an agreed architecture and a set of standards.

The Joint Logistics Commanders Guidance for the Use of an Evolutionary Acquisition (EA) Strategy in Acquiring Command and Control (C2) Systems contains, for example, a number of areas requiring special consideration when using evolutionary acquisition. These areas need review from the joint acquisition perspective, regardless of whether an evolutionary acquisition strategy is used in a joint acquisition program for a command and control system. Similarly, the Joint Logistics Commanders' Guide for the Management of Joint Service Programs needs review from the perspective of command and control systems, since that guide should minimally address the Joint Logistics Commanders' own evolutionary acquisition policy.

## CONCLUSION

Evolutionary acquisition, as an acquisition strategy, is neither widely used nor well understood. It is, if fact, so unknown to joint acquisition programs that the basic guide to joint acquisition programs omits any mention of evolutionary acquisition. Yet, one common thread between an evolutionary acquisition "strategy" and a joint acquisition "program" is that both have unique modifications to the normal practices of systems acquisition. Are these unique modifications compatible?

Based on the Packard Commission's criterion (an informed trade-off between user requirements, on the one hand, and schedule and cost, on the other), the conclusion is: No, an evolutionary acquisition strategy is not suitable to use in joint acquisition programs for command and control systems.

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# [illegible] SYSTEMS DON'T MEAN MORE DEFENSE

[illegible] R. Judson, The RAND Corporation

ABSTRACT

The Department of Defense (DOD) procedures for establishing major weapons systems minimize the potential contribution of any given system to increasing overall defense posture.

## INTRODUCTION

### Best Defense

There is no real defense budget for decision making, only the unreconciled budgets of the Army, Navy, and Air Force with their individual perceptions of defense needs. Hence, decisions for weapons systems requirements are not disciplined to account for their contribution to a concept of best defense -- that is, a defense-wide context of needs and capabilities.

Many more systems are initiated than can ever be fully funded. Maintaining unrestrained initiations often has the effect of "robbing" other systems, resulting in program stretch-outs, cancellations, or reduced force levels. These are random adjustments made one at a time, not a coherent modification of an overall concept of best defense.

### Competition

DOD procedures permit, but acquisitions are rarely based on, real competition -- that is, selecting the best possible answer from competing conceptual or design alternatives to meet a confirmed need, and to do so at that point in development where life-cycle costs may be projected based on proven design features. Premature lock-in to single system "answers" to assumed needs, or premature lock-in to specific technologies, build in the adverse characteristics of the majority of weapons systems acquisitions -- namely, schedule slippage, performance shortfall, and cost growth.

### Integrity

The inevitable consequence of adverse characteristics that flow from the way systems are initiated invites service attempts to minimize public concern with poor results, such as performance. Efforts to minimize exposure of adverse characteristics degrade the integrity of major weapon system management. Not infrequently, the result is introducing marginal equipment into inventory by circumventing the minimum review and approval process for validating new systems. The cumulative effect of never reconciling separate defense perceptions -- buying prematurely by services to capture a share of limited resources, and not facing squarely the performance degradation and compromises which follow -- results in weapons systems decisions where more defense dollars are not buying more net defense.

(Text of Paper)

## ABSENCE OF DEFENSE BUDGET

The service acquisition programs are shaped by their separate views of defense missions and priorities. The needs and goals which the services see for themselves do not necessarily correspond to the perceptions of the other services or of the Office of the Secretary of Defense.

Major systems acquisitions are the principal means by which services can preserve and enlarge their roles, budgets, and influence; and the requirement that the services defend a system before large-scale resources are committed creates an incentive to focus prematurely on the technical approach. Resources are spent to prove that the initial choice is right, rather than to examine broad alternatives.

The services have been permitted to run "wide open" in deciding what their needs and goals should be. More programs are initiated than can possibly be supported. Services end up diluting existing programs to back the next round of acquisitions.

Service perceptions are not reconciled among the services, or even within the services. An easy example of services unreconciled among themselves is that each service has assumed a role of close-air support; although the Air Force, alone, is designated to perform this mission. Because the Air Force never took the assignment seriously and is currently not even certain it wants the assignment, the Army (otherwise forbidden fixed-wing aircraft) tried to meet the close-air support mission in large part with helicopters, a cumbersome and often ineffective way to meet these needs. For its part, the Marine Corps utilized the Harrier aircraft. The Air Force has decided not to purchase another production run of its latest close-air support design, the A-10 aircraft, and has half-heartedly offered another version of the F-16 as an alternative.

Interservice rivalry for the close-air support mission, planned and controlled, might have produced an optimum system for the mission. If competing alternatives had been pursued under a controlled situation, billions upon billions of dollars would have been saved and, more importantly, the mission could have been met. As it is, we have a series of second-rate answers; an aircraft the Air Force doesn't want for a repeat buy; the helicopter pressed into a role it is often not equipped to perform; and a Navy answer (Harrier), probably the best of the three approaches despite range and support issues. The same absence of reconciliation to a defense mission occurs within a service where there is no interservice rivalry for performance of the mission.

Although less visible than interservice rivalry, intraservice considerations for reconciling among competing points of view may also lack an overriding consideration of best defense. An example would be sea control. There is no contest with the Air Force or the Army to perform this Navy mission; but, within the Navy, there are several approaches to meet the mission need. Sea control could be achieved by surface or subsurface ships, aircraft, submarine- or aircraft-based missiles, or some combination of these approaches.

Every system promoted by various interest groups within services, which finds its way into formal approval, has a ripple effect on existing systems and limited resources. These new systems are introduced without a stringent review within the service or at the Office of the Secretary of Defense (OSD) level against a best defense standard, and generate their own territorial imperatives. The territorial imperatives survive Congressional review, where debating one system at a time, rather than considering an entire defense mission, is the rule.

There are important and verifiable insights into services running "open loop" in initiating new systems. Selected Acquisition Reports (SARs) are congressionally required reports, above a certain dollar threshold on the current and projected costs of systems acquisitions. The source of information is the suppliers, so the estimates are conservative.

Currently, there are approximately 99 of these systems having a supplier estimated acquisition cost of about 850 billion dollars. If one uses the multiplier of two or three times acquisition cost to cover operations and maintenance costs during the life of a system, presently there are systems under contract which will require up to three trillion dollars of total funding. No defense budget that can be imagined could support full funding of this current commitment, even spread over the life of the systems, and still provide for conventional arms and the required service personnel for both. As a result, systems will be eliminated, stretched out, have reduced quantities, be multi-missioned or otherwise manipulated, to try and keep a wave of overcommitment from swamping the decision-making process. None of these coping devices is the result of a comprehensive review of all systems in a total defense context but, rather, ad hoc adjustment to keep a parochial decision-making system going.

Major systems, like the Sgt. York gun, have been cancelled after the expenditure of billions of dollars, or quantities have been reduced (such as most fighter programs), or programs have been stretched out. None of these adjustments is measured against a comprehensive concept of best defense. Whatever happens to net defense capability just happens.

Last year, DOD was forced to make budget cuts in order to avoid Gramm Hollings Rudman (GHR) automatic budget reductions. Eventually, 31 programs, totaling some 33 billion dollars, were cut. These cuts weren't made on a coordinated basis against a standard of best defense. Rather, each service was allocated a dollar cut total and the programs were either cancelled or stretched out, irrespective of their net impact on a concept of best defense. No one was monitoring that impact and using it as a basis for deciding where cuts could or couldn't be made. How meritorious were these 31 programs in the first place? Can the reader name any of them? If they are that optional to our defense needs, how did they get initiated?

A more current example of the lack of discipline in decision making for defense needs is the recent need to cut $50 billion from the current five-year defense plan in order to balance the books with internal DOD spending targets. Again, this must be done to avoid automatic GHR cuts. A defense plan had been approved by the Defense Resources Board (DRB) without reflecting the total cuts required to meet the $50 billion target reduction. So, the task of coming to grips with the final required reductions was given to the DOD comptroller! No concept of best defense here. The comptroller makes an arbitrary dollar reduction allocation to each service. It is random entry for systems and random exit -- hardly the basis for establishing a concept of best defense.

What were the merits of systems in the first place which exit at random, which were squeezed out by a new wave of systems, which were overtaken by budget cuts because the national debt has doubled in the past few years, or which failed to beat the cut of the comptroller. Who is in charge of defense?

## COMPETITION

What passes for competition in most major weapons systems first production buys is intense rivalry, not true competition in the sense of affording the government a wise choice among competing alternatives to meet a confirmed defense need.

Initial price for the first production run of a major system represents only one-fourth to one-third of the total cost of a system. Therefore, it is a poor basis for the selection of an awardee. Systems can be designed to minimize initial acquisition costs, at the expense of later operations and maintenance costs which the selection process doesn't evaluate.

Any major system production buy decision that isn't premised on life-cycle costs isn't a wise decision.

The vulnerability of an initial price, winner-take-all system, coupled with best and final offer procedures, is the principal entry point for compromise as seen in the pending allegations of scandal in trading privileged information for payoffs.

## INTEGRITY

The inevitable pressures to "look good," in terms of a service commitment to any given system, are so extreme that they often have the services defending marginal systems and bringing these systems into operational use. "Look good" is thought to be a requirement in order not to detract from the next round of appropriations considerations. Thus, the services are in the ironic dilemma of playing an appropriations strategy that nets them marginal systems they know to be less capable than represented and, in some cases, degrading to overall defense capabilities. A good example of this process is the compromise in operational test and evaluation procedures.

Congress had hoped to establish an independent operational test and evaluation function in DOD. The reality is that Operational Test and Evaluation (OT&E), like the Joint Chiefs of Staff (JCS) and the Office of the Secretary of Defense (OSD), is a captive of a process that makes the services independent of a concept of best defense and any reconciliation role of JCS and OSD to achieve a best-defense goal.

OT&E will not upset the territorial imperatives of the services nor embarrass the system with finding adverse to service interests. Neither will the JCS or OSD. An example is the much-discussed Aegis system which identified an ascending commercial Iranian aircraft as a rapidly descending Iranian military fighter. In a recent General Accounting Office (GAO) report on OT&E that included the Aegis system, GAO found that ". . . each of the (OT&E) reports to the Congress that we reviewed contained incomplete or inaccurate statements, and most contained both. . . . The omission, inaccuracies, and overall assessment consistently represented a more favorable presentation to the Congress of test adequacy and system performance than was warranted by the facts."

Before each Aegis radar test, GAO found that information was posted on bulletin boards, noting which mock enemy planes would attack, where they would come from, and which weapons they would fire. After spending 32 billion on a weapons system, any fault was clearly going o be the operator's and not the system's. To the explanation that the Aegis was intended for open-ocean warfare, one must ask if sea control isn't a world-wide concept and, if so, why not the Persian Gulf?

Just to round out service examples on the issue of integrity, one can cite the Army's Bradley Fighting Vehicle, where some 6,000 units will be delivered for troop use before completion of definitive testing of an extremely controversial and often demonstrably inadequate design.

The Air Force B-1 Bomber's ALQ-161 Defensive Avionics is another example of a known deficiency, shielded as long as possible from view -- the defects of which left the aircraft with no ability to counter Soviet attacks from the front.

Thus it is, at the end of the major acquisition process when we have a final chance to assess the merits of the equipment we provide the troops, we pay the final price for our requirements determination process: marginally effective, often unnecessary and, sometimes, unworkable systems.

At the point in time where both integrity and the systems are failing, the services have no alterrative but to tough it out. There are no alternatives to the marginal system, and no one can face the funding implications to generate an alternative.

The locked-in position self justifies the compromise in integrity. If there is nowhere to move, integrity is a moot point.

## SOLUTIONS

The suggested solutions which follow do not require new laws or reorganizations. A modified presentation of budget and some refinements in regulations are required, but the major change is one of attitude on the part of the services -- a change which should follow a realization that their own self interest mandates the change.

The two fundamental reforms are budget presentation and management of the early phases of requirements determination.

### Budget

The budget must be presented by defense mission elements -- that is, by units of operational capability which would force consideration of budgets in a total defense context.

Thus, if a mission element were a "tank battalion, to be operational it would need not only tanks but trained tank crews, trained maintenance personnel, command personnel, operating fuel, spare parts, supplies, pay and subsistence for personnel, weapons/munitions, support from division, support from brigade, etc."

Any worthwhile consideration of a defense budget should be in terms of units of operational capability.

Presentation of a defense budget, on this basis would force a realistic look at total costs. These same cost considerations would be part of the criteria for judging life cycle costs when selecting a new system. As it is today, separate system-by-system budget displays lack any focus and connection to a concept of operational capability and, thus, to total defense.

A mission element budget would force interactive discussions among the services, Office of the Joint Chiefs of Staff, and the Office of Secretary of Defense, which do not now take place.

In his recent testimony regarding the current acquisition scandal, former Deputy Secretary of Defense, David Packard, castigated the Joint Chiefs for not imposing discipline on the military services which "promote their individual strategies and their pet weapons" at the expense of a unified national strategy.

A better case can be made for the needed reconciliation process between OJCS and the Secretary of Defense, with OSD taking the lead.

In recent years, it has been the Office of the Secretary of Defense which has permitted the services to run wide open and, given those ground rules, JCS wasn't about to take the initiative to institute orderly decision making. Congress, too, is part of the problem. A line item, system-by-system budget is a constituent-oriented budget. Congress should be made to account for its debates and not infrequent parochial decisions to support favorite systems in terms of total defense impacts, not arguing the merits of one system at a time. Congress is in the best position to mandate budget format and content and guarantee the reform in system decision-making that must come about as the result of changed budget presentations.

Requirements Determination

The critical phase of weapons system decision-making is the period from concept formulation to program initiation. Preserving the integrity of concept formulation, the search through the technology base for the best answer to a confirmed need is the key.

More often than not, program initiation is made coincident with concept formulation. This locks in service requirements and locks out innovation; competitive conceptual and design alternatives are not brought forward.

Requirements determination reforms must institute a protection for the concept formulation phase that precludes the premature lock-in. This has been the antithesis of service functioning and requires a major reform in weapons systems decision-making for the services.

There will be an increase in the time taken and the R&D funds expended to guarantee the integrity of the outcome. However, the trade-off for this is the present system of locked-in requirements, an avalanche of paperwork and controls, high start-up investment, and marginal system designs outcomes. A few classic examples of a reform approach can be found in some past successful projects, such as the Navy programs for Polaris and Poseidon.

We have defended against reforms for years, saying that we never had the time and money to do it right, when the point has been that we have taken infinite time and money to do it over.

Production must be precluded before development is finished. Operational test and evaluation must be thorough and complete. We can't continue to field systems with design flaws.

Prototyping ought to be a standard before any commitment to production. Another example of doing it right, utilizing prototypes, is the Air Force Lightweight-fighter Program, now more than ten years old.

CONCLUSIONS/SUMMARY

Because of our procedure for initiating major weapons systems, we now have many more systems than can be supported by even the most optimistic budget outlook. We are fielding systems with design flaws, falling well below the expectation of a contribution to total defense. There is no shared understanding between the legislative and executive branches, or even within the executive branch, of the merits and contribution of any given system to total defense. We are dealing with one system at a time, crossing our fingers that it will all come out all right, but it doesn't.

## NEEDED REFORMS TO THE DEFENSE SYSTEM MANAGEMENT OF AVIONICS ACQUISITION AND SUPPORT

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### ABSTRACT

Modern avionics rarely experiences total failure. Instead, it falls victim to faults that erode its performance. Symptoms of even serious degradations are often subtle, and especially so for infrequently exercised combat avionics equipment. Such faults can create perplexing maintenance problems, with the result that malfunctioning equipment often rotates between shops and airplanes. Such revolving-door circulation of unrepaired equipment futilely expends time, test equipment and spares. More important, it means that aircraft are frequently flown with avionics equipment that cannot perform at full potential. As avionics systems continue to grow in scope and complexity, the need for fundamental reform becomes increasingly critical. This paper proposes a cohesive set of specific reforms to the management of both the acquisition and support processes directed toward significant improvement in reliability and maintainability (R&M).

### INTRODUCTION

The image of classic aerial combat as a succession of swirling dogfights along World War II lines has been overtaken by advances in technology. So too has the image of massive waves of combat aircraft attacking targets on the ground.

With the advent of long-range radar and instrument-guided missiles, air battles may be engaged and the outcome decided long before the adversaries come within sight of each other. Even when the final fight is at close range, the pilot's long-range awareness of his situation and positioning relative to the enemy is critical. Further, with improved radar, infrared and optical sensors and target-designating lasers, attacks on ground targets may be accomplished with far fewer aircraft than in the past.

#### The Challenge

The pilot of today's combat aircraft depends upon this complex array of interdependent electronic systems not only to help him track and destroy targets in the air and on the ground, but to counter the electronic measures taken by enemy pilots and ground-based air defenses.

Spurred by the need to ensure the continued superiority of the nation's combat aircraft, the drive toward more and increasingly complex aviation electronics ("avionics") will continue far into the future.

Although critics of this trend may expect these magnificent machines to go the way of the dinosaurs, victims of their growing complexity, the parallel is not the dinosaur but a young race horse with fabulous potential. Whether he will realize that potential depends on how carefully he is brought along.

As with a horse race, the outcome of aerial combat between closely matched adversaries or of air attacks on well-defended targets is never a sure thing. Faced with the increasing sophistication and capability of enemy aircraft and ground-based air defense systems, our pilots need combat electronics that will dependably deliver the full measure of their capabilities [1,2,3].

The military services can assure that dependability if certain major weaknesses are corrected in the process by which avionics are developed and supported [4,5,6,7]. This view is supported by nearly 25 years of Air Force-sponsored research at RAND on avionics acquisition and support. Previous projects have involved various models of the F-4, F-111 and A-7, while the recent work has focused on the F-15 and F-16. The only two Air Force fighters introduced since the 1960s, both aircraft will remain in service for at least another two decades.

Although the problems and ideas discussed in this paper come from research that was sponsored by the United States Air Force, those familiar with other military services will recognize many of the difficulties discussed in this paper.

#### Fault Isolation Problem

In contrast to the past, modern avionics equipment rarely experiences total failure. Instead, it falls victim to faults that erode its performance. This degradation is often subtle — a loss of range in target detection, perhaps — and difficult to observe except when the equipment is performing certain operations or in certain environments. Flaws in a fire control radar, for example, may manifest symptoms only when the aircraft is executing a violent maneuver.

Flaws with such nonstationary observability are called Type B faults to distinguish them from faults that steadily manifest symptoms (Type A).

The elusive Type B faults create perplexing repair problems with the result that malfunctioning equipment often rotates between shops and aircraft until it acquires a more easily observable fault. Some sense of the magnitude of the task of isolating faults can be gleaned from the fact that a single avionics shop may require any one of 40,000 types of replaceable parts and assemblies to keep its test equipment functioning.

The revolving-door circulation of unrepaired equipment wastes time, test equipment and spares [5,7]. More importantly, circulation of such "bad actor" equipment means that aircraft are frequently flown with avionics that cannot deliver its full potential. While such a situation entails little risk on training flights, it could be a serious matter in actual combat.

**Weaknesses in the Support Process**

Avionics technicians attempting to fix these faults are hindered by two primary weaknesses in the support process [5,7]:

- Routine peacetime missions provide limited opportunities to evaluate equipment such as fire control radars, air-to-air missile launchers and electronic countermeasure equipment.

- Maintenance workers lack effective equipment for identifying and correcting faulty electronics that are circulating between aircraft, shops and depots.

**Weaknesses in the Acquisition Process**

Turning to the future, the acquisition process also has weaknesses that contribute to degraded performance of combat critical equipment [5,7]:

- Avionics contractors are seldom aware of the extent and nature of problems plaguing the maintenance teams and, as a consequence, pay inadequate attention to these problems in the design of new equipment and their support systems.

- Designers, working on the cutting edge of fast-moving technologies, have little engineering data to support their designs and lack precise information about how their equipment will be used or how harsh its operating environment will be. By the time early operational experience could be used to clarify these matters, the designers are no longer involved.

- Stiff competition for large, long-term contracts often leads developers to promise more in the way of schedule and performance than they can deliver. In any case, prevailing pressures to shorten the length of the acquisition process leave insufficient time to test and refine equipment before it is delivered in large numbers to operational squadrons.

- Finally, before contractors have resolved problems that arise in the critical initial years of avionics operation, the Air Force transfers engineering management responsibility from the weapon system's program office to one or more depots.

While acknowledgment of these weaknesses lends fuel to the critics' arguments, it is a vital first step in harnessing the full potential of mission essential avionics in combat aircraft.

## A STRATEGY FOR REFORM

A recent RAND report [5] proposes a six-part strategy to help the Air Force accomplish needed reforms to the processes of supporting and acquiring avionics:

Proposal 1: Speed up development of technologies that not only promise to greatly increase the performance of avionics equipment but also to improve reliability and ease of maintenance. These include very high speed integrated circuits and gallium arsenide circuits, both of which will increase computing speed, and electronically steered antenna to replace mechanical scanners. In particular, there is a need for improving the test technology incorporated in the avionics of combat aircraft. These built-in tests have considerable "unfulfilled potential" for pinpointing elusive faults.

Proposal 2: In the aircraft, on the flightline, in the shop and at the depot, capitalize on available technology to improve avionics test equipment. Faulty units often slip undetected through several layers of maintenance because tests inevitably differ from cockpit to shop to depot. Among the needed improvements is a test translation dictionary to enable technicians at the various levels of maintenance to "speak the same language." This would help to ensure that the fault occurring in flight is the fault repaired in the shop.

Proposal 3: Improve the quality of information pilots give to technicians in postflight debriefings and provide technicians with better computer programs and hardware for identifying and tracking hard-to-fix faults. Incomplete reporting by pilots of all of the symptoms of malfunctions that they experience during a flight is one of the chief reasons faults go uncorrected. Another is the lack of an effective computer-aided system for identifying equipment with peculiarly high maintenance demands relative to their time in operation.

Proposal 4: To attract management attention to the most serious fault-isolation problems, the report proposes the adoption of a measure of fault removal efficiency. The measure would provide a comprehensive gauge of the overall support system's ability to remove faults and could be key in focusing product improvement on the areas of greatest need.

Proposal 5: Add a formal phase to the avionics engineering and development process that would focus on early operational experience with the more complex equipment, such as fighter radars and their associated support systems. Time and funds should be allocated and milestones identified in the program management plan to provide for this two-stage process that the authors call maturational development:

- In the assessment stage, contractors will collect and analyze engineering data on their equipment to determine where, how often and why an avionics subsystem fails to deliver the full measure of its designed capabilities. Following this, they will formulate a comprehensive package of proposed improvements to cover the airborne electronics, the ground-based test equipment and the maintenance procedures for both.

- In the implementation stage, they will put into operation the most cost-effective improvements that aim at regular delivery of full design performance.

During 1984-1985, in a joint Air Force-industry-RAND effort, the assessment stage of the maturational development concept was applied to combat radars in the F-15 and F-16, at a cost of $6 million for each demonstration application. With the demonstration showing well over 1,000 radars in need of significant R&M improvements, the cost of implementation would be about $500 million.

While some maintain that these costs show the maturational development concept to be unaffordable, the costs must be weighed against the benefits—namely, that these improvements are necessary to accomplish the goal of dependable delivery of full design performance. Moreover, by far the largest portion of the $500 million is accounted for by the cost of modifying the radars, an expense that could have been much smaller if the design improvements had been incorporated at some point during production.

One of the most important lessons of the demonstrations, is the need to start full-scale development of complex equipment like radars ahead of the airframe, so that improvements can be incorporated on the production line rather than by means of costly retrofits.

Proposal 6: To assure full benefit from implementation of the first five proposals, the report proposes that the Air Force rethink the organization of its avionics engineering resources. Specifically, it should consider creating an Avionics Engineering Center to provide continuity during the research, development and maturation of complex avionics subsystems.

## IMPLEMENTATION

In a March 1988 interview in *Air Force Magazine*, General Larry Welch, Air Force Chief of Staff and former commander of the first operational wing of F-15 aircraft, endorsed the concept of a maturation process:

> "Today's weapon systems are highly complex. A maturing process is required during their testing and following their introduction into the force. It is unrealistic to expect perfection of them at the point of their introduction. ... There is no possibility of testing a new weapon system in an environment that will cover all the circumstances—all of the things that it will be subjected to—in an operational environment, and we believe that this is the most effective approach. ... The time and cost that would be involved in trying to introduce initially perfect weapons into the operational environment would be prohibitive."

Moreover, the Tactical Air Command has

- Requested the incorporation of a capability into the Air Force's core automated maintenance data system to facilitate the identification of bad actor equipment.

- Joined with the Air Force Logistics Command to formulate a bad actor identification and recovery program.

Meanwhile the Air Staff and others have been examining the issue about the organization of the Air Force's avionics engineering resources.

Currently, the main issues are

- Should there be standard policies and procedures for managing the maturation process?

- Should the Air Force reorganize its avionics engineering resources?

## POLICIES AND PROCEDURES NEEDED FOR THE MATURATION PROCESS

Goals such as speed of development and minimization of development expenses are at conflict with the time and resources that are required to mature a complex subsystem that relies heavily on leading edge technologies.

Avionics acquisition programs have overemphasized speed of development. Much can and should undoubtedly be done to remove many of the bureaucratic inefficiencies that currently slow down the acquisition process. We cannot fight enemies with weapons that are still on the drawing boards. But an undue emphasis on speed of development has lead to a failure to

- Collect accurate and relevant data concerning potential problems with sustaining a weapon system's designed performance.

- Redesign portions of the weapon system and its support system to avoid these problems.

When fielding new weapon systems, we have been preoccupied with the time to initial operational capability (IOC) and have largely ignored the time to *matured* operational capability (MOC). The latter can take much longer, as can be seen in the time needed to introduce radar R&M improvements for the F-15 and F-16.

To assure that development programs have appropriate maturation processes, policies and procedures must be established to force proper balancing of performance, schedule, cost, and maturation. To establish proper policies and procedures, one must first adopt a clear concept of what a subsystem maturation process should include. The following model provides a concept that could be prescribed for the most challenging subsystems, such as radars and electronic counter measure equipment.

## MATURATIONAL DEVELOPMENT: A CONCEPT FOR MATURING SELECTED AVIONICS SUBSYSTEMS

### Stage 1: Assessment of R&M Situation

The objective of stage 1 is for the subsystem contractor to take the lead in working with the weapon system prime contractor, the support equipment contractors (hardware and software), and the government in a team effort. The effort would define a comprehensive package of R&M improvements that addresses the most serious R&M deficiencies in:

- The subsystem of interest.
- The interfaces among the subsystem of interest, the host weapon system, and related subsystems.
- The support process at all levels (cockpit, flightline, shop, and depot) for the subsystem of interest. This includes tests, test equipment, test software, and maintenance instructions (Technical Orders, or TOs).

To assure a forthright and comprehensive assessment, the effort would proceed on a no-fault basis, the philosophy being that it is more important to identify and resolve complex problems than to cast blame. Accomplishment of the objective requires four major activities, each needing considerable involvement by the aforementioned contractors:

1. Collect data based on operational experience to determine where, how, how often, and why a combat-essential avionics subsystem fails to deliver the full amount of its designed capability.
2. Analyze the data to identify the most serious deficiencies in terms of the effect on dependable delivery of the subsystem's designed capability.
3. Define candidate actions to correct or remediate the most serious deficiencies and analyze the prospective cost and benefits.
4. Work with the government to define a comprehensive package of actions to improve the R&M situation for the subsystem of interest.

### Stage 2: Implementation of Improvements.

Stage 2 of maturational development involves carrying out the improvements, some of which can be expected to require further development efforts.

## CURRENT ORGANIZATION OF AVIONICS ENGINEERING RESOURCES

The overall effectiveness of any maturation process is influenced to a very great degree by how a military service applies its limited avionics engineering resources.

### Diffusion of R&M Responsibilities

Diffusion of R&M responsibilities occurs throughout the acquisition process. It becomes especially acute when the Weapon System's System Program Office (SPO) starts anticipating program management responsibility transfer (PMRT) for avionics subsystems. By its very nature, the advent of PMRT forces the SPO to start closing out its engineering responsibilities. It is therefore the wrong time to start new R&M improvement initiatives. Moreover, once PMRT occurs, responsibility for an avionics subsystem passes to one organization and responsibility for the shop's intermediate test equipment passes to an entirely different one, usually located at a different air base.

### Lack of a Single Organization to Manage Implementation

For the ongoing efforts to mature the F-15 C/D radar and the F-16 A/B radar, the Aeronautical Systems Division Strike SPO was made responsible for the Stage 1 assessment of the R&M situation, but no single organization bears responsibility for coordinating Stage 2 (implementation of improvements) for either radar. For a while the Strike SPO helped fill the gap on several of the generic improvements. However, resource limitations of the Strike SPO together with personnel limitations at the depots have constrained the extent of this involvement and thus restricted the pace of the implementation.

### Not Allowing Depots to Use Development Funds to Undertake Engineering Development of Improvements

One limitation at the depot is the policy of not allowing depots to spend development funds (so-called 3600 money) to fund engineering development of needed improvements. This has hindered development of a new line replaceable unit for the F-16 A/B radar.

Awareness of such difficulties with the current organization of avionics engineering resources has contributed materially to thinking about the concept of an Avionics Engineering Concept. Following is a vision of how such a Center might be organized and how it might function in ways that would address the problems discussed in this paper.

## A VISION FOR ORGANIZING AN AVIONICS ENGINEERING CENTER

The Center would provide broadly ranging expertise and corporate memory, including detailed knowledge of forthcoming threats, R&M problems in the field, ongoing development efforts, and potential roles for emerging technologies. It would apply such a knowledge base and its engineering expertise to Air Force avionics efforts ranging from advanced basic research through maturation of fielded equipment.

The Center's primary objectives would be to

- Develop advanced plans to meet future needs.
- Formulate guidance for Air Force and industry research.
- Review the allocation of resources to laboratory programs relating to avionics.
- Manage advanced development of critical components, subassemblies, and prototypes for future subsystems.
- Manage development of avionics subsystems that are applicable to multiple weapon systems.
- Manage development of avionics subsystems for major weapon systems in those situations where the weapon system SPO chooses to assign management responsibility to the Center.

- Manage R&M maturation programs for selected subsystems.

Secondary objectives for the Center would be to assist:

- Weapon system development programs.
- Product improvement programs.
- User formulation of statements about forthcoming needs.
- Development of advanced concepts.
- Threat assessments.

As envisioned here, the already sizable Avionics Laboratory would continue to focus on advanced research and would operate separately from the Avionics Engineering Center. Although operationally separate, the laboratory's planning function would benefit from the Center's planning activities. Moreover, the Center would review the allocation of funds for the laboratory's advanced research programs. To minimize the opportunities for conflicts of interest, funds for advanced research should remain separate from funds that the Center would apply to its own programs.

To accomplish the foregoing objectives, the Center would need to undertake activities within four major areas:

- Field assessment.
- Technology management.
- Development management.
- Planning.

**Field Assessment**

Activities in this area would acquire, archive, and distribute information about R&M deficiencies being experienced in the field. This area would be a key source of information for each of the three other major areas. To fully accomplish its purpose, this area would need to launch and support efforts aimed at five objectives:

**1. Manage data collection and analysis.** Activities that would support this objective include managing Stage 1 (Assessment) of maturational development and routinely extracting relevant information about field problems from the Air Force's standard data systems.

**2. Archive and distribute information.** Activities that would support this objective would include distilling lessons learned from Stage 1 maturational development programs, archiving such information, and distributing it in an appropriate format. Distribution should include SPOs, contractors, and appropriate laboratory programs.

**3. Improve data systems support.** Activities here would include developing and supporting special data collection procedures to support Stage 1 applications of maturational development, and specifications for needed improvements to Air Force standard data systems.

**4. Improve application of test and evaluation resources.** Two activities are essential here: improving airborne and ground-based test and evaluation resources and scheduling available assets.

High on the priority list should be the development of facilities to: (1) evaluate operational avionics equipment such as radars and ECM, and (2) measure environmental parameters within avionics subsystems.

**5. Coordinate field assessment programs.** Coordination would need to occur in three directions. Lateral coordination would be needed for Technology Management, Development Management, and Planning, and product improvement programs to assure that the Field Assessment area understands the needs of the other areas and the opportunities to contribute. Upward coordination would be required to secure adequate personnel and funding resources. Internal coordination within the area would be required to schedule resources against priority needs.

**Technology Management**

The purpose of this area would be to assimilate information about evolving threats, R&M deficiencies, and emerging technologies and use such knowledge to help manage the development of technology from basic research through subsystem prototypes. This area would use information from the Field Assessment and Planning areas and indirectly would be a major supplier of technology for the Development Management area. To fully accomplish its purpose, this area would need to launch and support efforts aimed at four objectives:

**1. Evaluate technology development programs.** Accomplishing this objective requires periodically reviewing technology development programs and their progress in light of needs — both performance and R&M — and in consideration of alternative approaches. The Air Force's portfolio of such programs would need to be evaluated for balance across four major divisions (basic research, critical component development, advanced assemblies, and prototypes). Review of investment balance — in light of needs — would also be needed within each division.

An initial high priority should be assigned to a review of programs in the critical component development division, with emphasis on the needs of next generation combat aircraft.

**2. Manage selected technology development programs.** This objective is aimed at important programs that — for whatever reason — fall outside the purview or interests of the laboratory. An example of such a program might be the development of critical components as a prelude to a full-scale engineering development effort. Another example might be the development of a prototype subsystem or assembly such as an antenna.

**3. Improve test and evaluation resources.** To adequately evaluate progress made by technology development programs, it is often necessary to develop or acquire special resources for test and evaluation. Activities here would provide such resources.

**4. Coordinate technology development programs.** As with the Field Assessment area, this area also would require lateral, upward, and internal coordination. Such coordination is especially crucial to assure the relevance and value of the products of technology development programs. An additional dimension of coordination here is the opportunity to help guide industry's internal research and development efforts.

#### Development Management

The purpose of this area would be to assimilate information about evolving threats, R&M deficiencies, and developed technologies and use such knowledge to help manage avionics development, including product improvement. In addition to the airborne equipment (including software), the scope of involvement would include ground support equipment, maintenance instructions (TOs), and training. This area would be a major consumer of information from the three other major areas: Field Assessment, Technology Management, and Planning.

To fully accomplish its purpose, this area would need to launch and support efforts aimed at seven objectives:

**1. Formulate and maintain development guidelines.** Activities aimed at this objective include development and maintenance of standards (Military Specifications) and processes. They also should aim at appropriate distribution of information about R&M lessons learned in related programs.

**2. Assist SPOs in managing weapon system or subsystem development.** Here the main activity would be supplying knowledgeable engineers to support SPO programs, especially program reviews. The goal would be to supply engineers with experience in at least Field Assessment and Technology Management.

**3. Manage any avionics subsystem developments not assigned to SPOs.** Management of development for certain avionics subsystems is done directly by the Air Force. Those programs not assigned to SPOs could become activities within the purview of this objective.

**4. Manage and coordinate Stage 2 of maturational development.** The main activities would be managing and coordinating Stage 2 of maturational development. For a given subsystem, an activity would manage and coordinate the implementation of the improvement package that the Air Force selects from the Stage 1 effort.

**5. Systems engineering and evaluation support.** Here there are two key activities. The first is to draw upon results from the Field Assessment area to evaluate the R&M situation with a subsystem of interest and share that evaluation with the cognizant program office. The second is to assure that adequate resources for systems engineering are applied to development of interface specifications whenever the Air Force takes on the responsibility for management of subsystem development.

**6. Improve test and evaluation resources.** As with the Technology Management area, to have the necessary test and evaluation resources adequately available may require special development and acquisition efforts. Electronic warfare and fighter fire control radar equipment are two classes of equipment in special need of such facilities.

**7. Coordinate equipment development programs.** As with the other major areas, significant coordination of funds, priorities, and resources would be required.

#### Planning

The purpose of this last major area would be to develop plans for the Center based upon evolving projections of the threat, evolving assessments of field R&M deficiencies, and emerging technologies.

### FINDINGS

An avionics engineering center formed along the lines of the preceding model would have the opportunity to:

- Sponsor advanced development of critical elements.
- Start FSED early for critical subsystems.
- Supervise maturational development for critical subsystems.
- Oversee post-PMRT maturation and engineering support.

#### Sponsor Advanced Development of Critical Elements

Just as the Engine SPO has sponsored advanced development of high-risk and technology-intensive components (such as gas turbine generators), so also could an Avionics Engineering Center sponsor advanced development of similarly complex and important equipment (major electronic assemblies, new architectures, digital communication protocols, etc.).

#### Start FSED Early for Critical Subsystems

Even with the benefit of advanced development of high-risk critical elements, some subsystems are sufficiently complex that they would also benefit from starting full-scale engineering development in advance of the airframe. Even the most sophisticated avionics equipment usually starts FSED after the airframe and engine. And once avionics FSED does start, it usually occurs without benefit of advanced development of its critical components. This practice made sense when combat aircraft consisted primarily of airframes and engines and when avionics equipment was added after designs had largely been completed. Now, however, avionics equipment plays a more central role in combat performance, and it accordingly overshadows most other equipment in cost, weight, volume, and complexity. It thus needs the early developmental attention customarily given airframes and engines.

#### Supervise Maturational Development for Critical Subsystems

The engine SPO already has a Component Improvement Program aimed at maturing engines. An Avionics Engineering Center should have similar responsibility not only for new avionics equipment but also for avionics equipment already in the field.

#### Oversee Post-PMRT Maturation and Engineering Support

An Avionics Engineering Center could be responsible for avionics subsystems both before and after PMRT. Such a practice would enable it to draw on information and experiences accumulated before PMRT to help oversee post-PMRT maturation and engineering support. In addition, so-called

Avionics Technical Assistant Contractors could provide not only technical assistance to the Avionics Engineering Center but also a stable base for retaining corporate memory. To ensure objectivity, such contractors would have no contracts with the government to develop hardware or software. Technical Assistant Contractors have been used for years by the Air Force to support ballistic missile and space programs; more recently, the Armament Division at Eglin Air Force Base has entered into such an arrangement.

## CONCLUSIONS

With the foregoing kinds of activities, an Air Force center of engineering excellence for avionics could lead the way in accelerating R&M-related avionics technologies (Proposal 1), improving the ability to test avionics equipment (Proposal 2), providing more complete feedback on equipment performance (Proposal 3), adopting a maintainability indicator (Proposal 4), and instituting maturational development (Proposal 5). The creation of an Avionics Engineering Center (Proposal 6) therefore is the linchpin for a cohesive strategy for reforming avionics acquisition and support.

Technological strengths can compensate for disadvantages in other areas only by coupling high functional performance with high reliability and ease of maintenance. Thus, the challenge is to maintain high performance avionics equipment that dependably delivers the full measure of its designed performance. To meet this challenge, we need to aspire to higher levels of excellence in avionics R&M, and most especially in maintainability. Current organization of the Air Force's avionics engineering resources, however, does not appear well suited to the challenge. Indeed, it appears seriously lacking in many important respects. Therefore, for avionics to achieve its full combat potential, we find a significant need for the Air Force to reform its approach to defense systems management for avionics.

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# PUBLIC POLICY ANALYSIS
# APPLIED TO THE
# DEFENSE ACQUISITION SYSTEM

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## ABSTRACT

The Defense Acquisition System (DAS) is in flux due to both legislative and executive efforts to improve the system. Changes undertaken to attack undesirable conditions often create a net reduction in effectiveness of the overall process. The Center for Acquisition Management Policy (CAMP), in support of its mission at the Defense Systems Management College (DSMC), has established a project to perform a systemic review of the DAS and recommend improvements. As an initial step, CAMP published Outcomes, Principles and Criteria - a Framework for Assessing Changes to the Defense System, in January 1989. That publication defined seven desired outcomes of the DAS.

Review of the DAS might typically employ a systems analysis approach. However, the authors perceived limitations and problems with that approach, and instead chose to apply Public Policy Analysis (PPA) techniques.

This paper describes the application of PPA to a DAS review, and summarizes the results to date. Some conclusions include recognition that the core DAS process is technical in nature and that other administrative activities should support that core process. Preliminary impressions are that the core process is well refined and effective. The CAMP project is defining the technical decisions chronologically in the life cycle of a defense system, in order to better define the related supporting activity and agents. This will lead to a comparison of what ought to be done to support the core process, versus what is done, and the formulation of subsequent recommendations for transforming to congruence.

## INTRODUCTION

The mission of the Defense Systems Management College (DSMC) includes study and analysis of the Defense Acquisition System (DAS). This function is performed primarily by the DSMC Center for Acquisition Management Policy (CAMP). The CAMP is composed of experienced senior officials, who jointly analyze defense acquisition issues, problems, and policies, and recommend constructive changes. The related findings go to senior-level policy officials including the Department of Defense Acquisition Executive and other Defense personnel, the Congress, acquisition policy makers, and acquisition executives of the military services.

When the President of the United States called for effective reform of the DAS at the beginning of 1989 (reference (a)), DSMC established a project under CAMP to review the DAS and submit recommendations for improvement. In this paper we report on a unique aspect of this continuing CAMP review. We are applying Public Policy Analysis (PPA), which addresses "what ought to be" as opposed to the usual system analysis of "what is."

Prior to applying PPA, CAMP identified and enumerated the desired outcomes of the DAS. They are shown in Table I, which was extracted from reference

| DESIRED OUTCOMES |
|---|
| MEET THE NEED OF THE USER |
| BE DELIVERED ON SCHEDULE |
| BE DELIVERED AT PLANNED COST |
| BE AVAILABLE WHEN NEEDED |
| BE SUPPORTABLE WITH EASE |
| BE AFFORDABLE THROUGH ITS LIFE CYCLE OF USE |
| BE COMPATIBLE WITH OTHER WEAPON SYSTEMS |

TABLE I

FIGURE 1


(b). Now we, the authors, are in the process of defining what the system "ought to be" in order to provide the desired outcomes. Figure 1 was developed to show the global nature of the project. We grappled with the problem starting at the national level and looking "back" into the DAS, then conversely looking from the core technical process (reference (c)) and proceeding "outward" toward global issues.

Surprising to many, we have not found major fault with the DAS core technical process in our review thus far. We suspect that significant opportunity for improvement lies in the support activities girding the core process. Included herein is the description of the PPA used, an evaluation of PPA as an application tool for the review, and a report on the preliminary findings related to the DAS.

Public Policy Analysis at DSMC

The DAS is a very complex process and we have found that when dealing in this arena, problem definition and solution using system analysis is very difficult. In February 1989 a group of CAMP and DSMC faculty members attended a seminar series on PPA, led by Dr. Bayard Catron of George Washington University. By choice, the seminar group selected the DAS Review Project as the application study. The thrust was to steer clear of the traps prevalent in starting with "what is," and instead focusing on "what ought to be."

This approach takes on a basic moral and ethical tone as well as system definition details. Specifically, paraphrasing Yehezel Dror in Applied Social Science and Systems Analysis, PPA is intended to add the following to system analysis:

- Penetration into underlying values, assumptions, and strategies. These include, in particular: a) exploration of the basic values at which policies should be directed; b) long-range goal research; and c) explicit analysis of alternative policy strategies (such as risk choices, incrementalism vs. innovation, and goal-oriented vs. resources development-oriented policies).

- Consideration of political variables, including: a) political feasibility analysis; b) evaluation of alternative political pathways for policy approval and implementation; c) examination of social power implications of alternative policies; and d) analysis of coalition needs and political consensus implications.

- Treatment of broader and more complex systems, involving: a) lower and new scales of quantification; b) necessity to satisfy multidimensional and diverse goals; c) uncertainty; d) institutional change as a main mode of policy change; and e) acceptance of min-avoidances (that is, avoidance of the worst of all bad alternatives).

- Main emphasis on policy alternative innovation, involving: a) creativity encouragement; b) sequential decision making, learning feedback and social experimentation, instead of models, simulation and detailed policy schemes; and c) much attention to new systems design, in addition to redesign of systems.

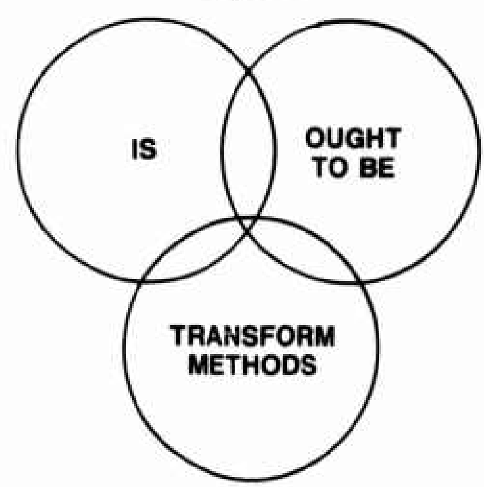
- Much sophistication in respect to social phenomena.

- Institutional self-awareness for instance in respect to the necessity for multiplicity and redundance of analysis.

The fundamental approach to PPA shown in Figure 2 has been accepted. The process establishes "what ought to be" and "what is" and then works on ways to bring about congruence. This turns out to be a very dynamic situation in the case of the DAS, because the "what is" changes as the study progresses. Likewise there are influences that can change "what ought to be." The trick is to reflect back and forth while responding to the dynamics.

The PPA seminar group addressed perceived reality (is) and desired values (ought to be) related to the Defense Acquisition System (DAS) in a brainstorming session. This was a first attempt at developing the conditions and at the time did not progress to further refinements or transformation issues at the DAS level.

FIGURE 2



## DAS REALITY (IS)

1. INDUSTRY DISINCENTIVES
2. BIAS TOWARD SHORT-TERM RESULTS
3. MANY FACTORS DRIVE DAS PROCESS INSTEAD OF SUPPORTING IT
4. SHORTAGE OF TRAINED, EXPERIENCED GOVT. ACQUISITION PEOPLE
5. INEFFICIENCIES
6. OVERREGULATION
7. QUALITY SHORTCOMINGS
8. TECHNICAL RISK OFTEN UNDER-ESTIMATED
9. PUBLIC DOESN'T PERCEIVE REAL THREAT
10. ADVERSARIAL RELATIONSHIP AMONG DAS PLAYERS
11. TAX STRUCTURE AFFECTS DAS
12. CONFLICT BETWEEN EGALITARIANISM AND CAPITALISM
13. THREAT CHANGES
14. INSUFFICIENT COMPETITION

TABLE II

## DAS VALUES (OUGHT TO BE)

1. MORE BUSINESS-LIKE
2. ACCOMMODATE THREAT CHANGES
3. TRAINED GOVT. ACQUISITION WORK FORCE
4. SATISFY USER (QUALITY, THREAT RESPONSIVE . . .)
5. SUPPORTIVE TEAM ENVIRONMENT
6. COMPETITIVE ENVIRONMENT WITH EMPHASIS ON VALUE
7. EMPHASIS ON COMPREHENSIVE, TIMELY, APPROPRIATE TESTING
8. APPROPRIATE INCENTIVES

TABLE III

Tables II and III list some of our perceptions based on the previous work by the seminar group, juxtaposing realities (is) and desired values (ought to be) in the DAS.

The authors felt the "is" condition to be well enough documented that the major efforts would be agreeing upon what "ought to be," and developing recommendations to bring the two into congruence. Figure 3 is a greatly simplified model of the process selected to define a DAS that will achieve the desired outcomes in Table I.

### The Defense Acquisition Systems

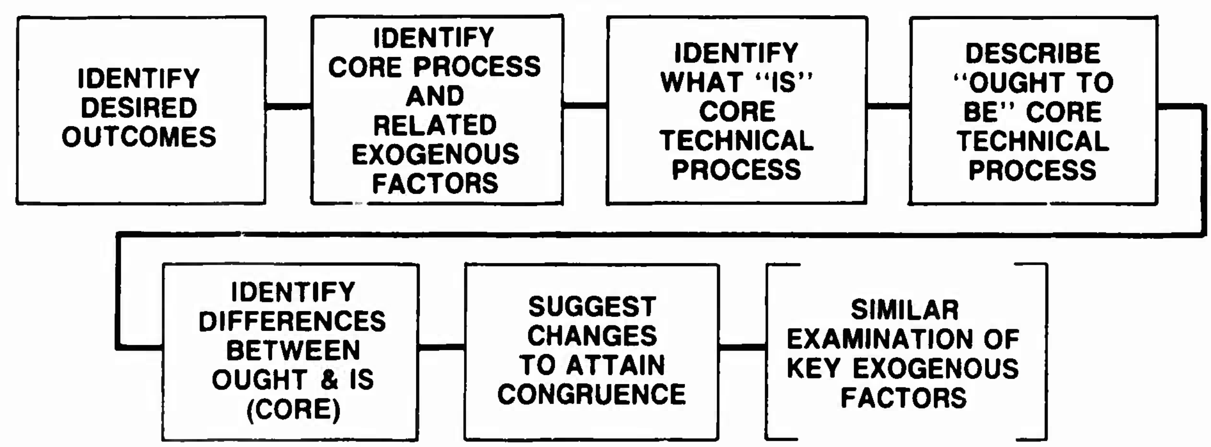
The DAS is described in a series of directives which in general drive the management process through a series of Milestones covering the life cycle of the system. The overall process is managed by a Defense Acquisition Board (DAB). DSMC has described this DAS in our Program Management Course covering the life cycle of a system. A well-defined bureaucracy has grown around this system. The DAS organizational structure has been revised several times in recent years, with one result being an organizational slide of the engineering leadership from the lead under-secretary of the DoD to a director within OSD. The DAS is under continual fire from the congress and the public because of the perception of fraud, waste, and abuse, and a congressional perception of lack of DoD responsiveness to constituents' desires and congressional wisdom. This reaction takes the form of continuing proposals for change of the DAS through legislation and/or more rules, regulations, and reports.

The prospects for change of the DAS remain high though the driving forces ebb and flow with the times. The Department of Justice project, "Ill Wind," will have an impact, as will the current Presidential initiative to implement the Packard Commission Report and reduce congressional micro-management.

### The DAS Environment

The Constitution of the United States of America clearly lays the responsibility upon Congress "To raise and support Armies," and "To provide and

FIGURE 3



maintain a Navy," in order to protect and defend the country. Congress, therefore, has developed a set of legal definitions for accomplishing the defense of the nation. These definitions take the form of legislation and are in turn reflected in Defense Federal Acquisition Regulations.

In recent years the amount of congressional oversight has increased at a great rate, largely fueled by greater public insight into the process and its output. The motives and accuracy of reporting on the DAS may be questioned but the value analysis continues. For better or worse from the standpoint of development efficiency, the defense of the nation takes into account the broad spectrum of congressional concerns (e.g., covering not only the broad economics of the country, but also the health and welfare of specific regional and business interests). The result is a plethora of legislation which is sometimes contradictory, often at odds with an effective engineering process, and currently tending to stifle effective management of competitiveness.

The prospect for altering this approach in Congressional oversight is uncertain, but forces for change are at work. DSMC has proposed that the Congress accept a reasoned set of guidelines for consideration in proposing changes to the DAS (reference (b)). The President has stated he wants to reform the system and called for implementation of an improved system.

Identification of the technical process as the core of the system was a basic building block for the authors in the review of the DAS. This finding flows from Figure 4 which shows the major players in the DAS, and their respective interests. Only the industry player operates a technical process and provides materiel. All other parts of the system should support that (core) endeavor.

FIGURE 4

**MAJOR PLAYERS AND THEIR ROLES IN THE DEFENSE ACQUISITION SYSTEM**

CONGRESS

LEGISLATIVE RESPONSIBILITY
SERVE CONSTITUENTS
RAISE, SUPPORT, PROVIDE AND MAINTAIN THE ARMED FORCES

EXECUTIVE BRANCH

PRESIDENT IS COMMANDER IN CHIEF OF THE ARMED FORCES
CREATE AND IMPLEMENT POLICY
CREATE REGULATIONS
PROVIDE - DIRECTION, OVERSIGHT, ORGANIZATION AND RESOURCES

INDUSTRY

SERVE CONSTITUENTS (STOCKHOLDERS)
DEVELOP AND PRODUCE HARDWARE

## PROBLEM DEFINITION

The technical process for DOD weapons systems is well defined. It encompasses research, development, engineering, production, operation, support, and product improvement. It is specifically defined in a set of directives for each participating service, and is covered in generic terms by the DSMC Technical Activities Life Cycle Chart (reference (d)). Further it can be identified as part of the Defense Acquisition System (DAS) in the "Sanders (Corporation) Charts" (reference (e)), the DSMC Systems Engineering Management Guide (reference (f)), and DoD "Risk Templates" (reference (g)).

The engineering process is impacted by constraints in the DAS. These include user (i.e., operational user and his superiors up to the JCS, SECDEF, Service Secretaries, and Service Headquarters), legal, and budgeting considerations. These impacts manifest themselves in: a) changing technical inputs to requirements throughout the process; b) fixed and changing legal requirements that reduce the efficiency and effectiveness of the process (e.g., rules for competition, small and minority business participation); c) difficult budgeting requirements which are insensitive to developmental uncertainty and risk, and d) instability of support.

The history leading to this situation starts after WWII, when engineering was at its pinnacle of success in Government systems development. The engineers controlled the DAS. They overwhelmed the "opposition" with success, and were given free reign in rules and expenditures. But the propensity to prolong laboratory gestation, at great expense, and to develop new and sometimes useless or ineffective products, led to a battery of restrictions when a budget showdown finally came. The restrictions took the form of justification of user needs, formal consideration of social concerns, detailed codification of legal responsibilities among parties, business considerations, and budgetary constraints.

The technical process as it now operates does not routinely achieve the seven desired outcomes (Table I) identified in the DSMC study (reference (a)). It is perceived that some changes can be made to improve the process and that recognition of the impediments that cannot be changed will lead to a better process.

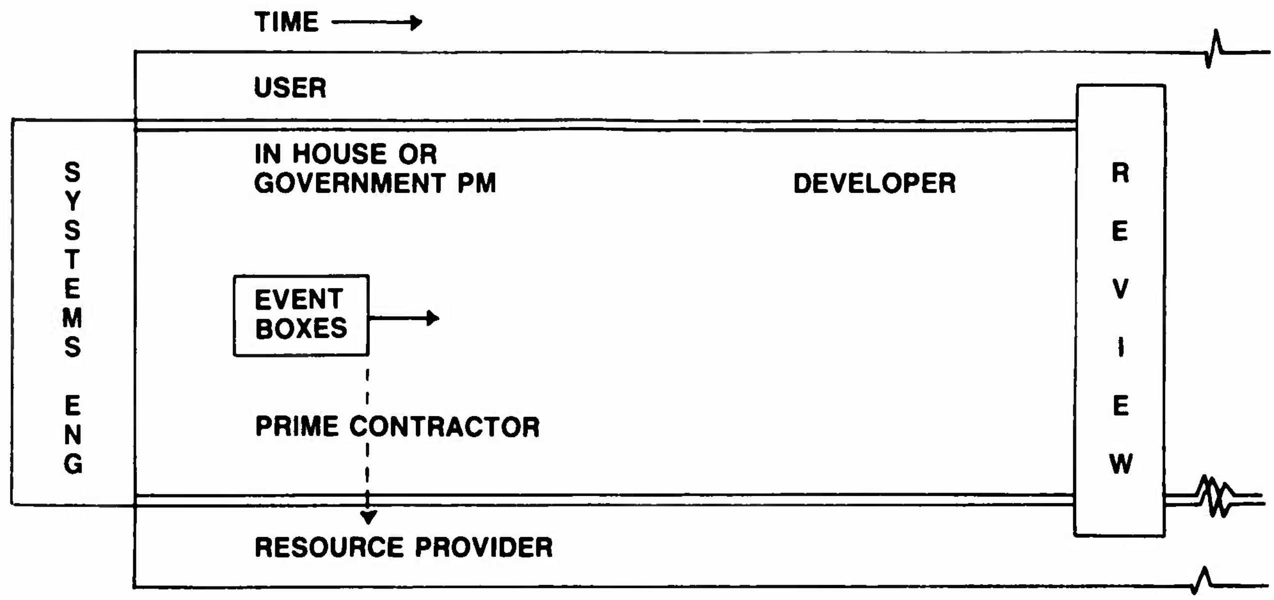
The technical process which has developed is adversely affected by:

- the encompassing DAS which grows and changes
- continuing congressional mandates for DAS management refinements
- continuing public pressure on defense issues
- continuing change in technical inputs occasioned by alteration of national strategies both domestic and foreign
- special interests
- PPBS influences driving the process instead supporting it.

The sum of these impacts represents a high rate of change in the environment which in turn impacts the DAS and the technical process.

FIGURE 5

GRAPHIC FORMAT




We must:

- identify the elements of change which can be controlled or responded to in an effective manner while achieving the desired outcomes through the technical process then implement the necessary responses.

- recognize those elements of change which will continue and develop appropriate techniques for minimizing the effect on the technical process.

The guiding query of our review is, "What is the best DAS that will satisfy the needs of the public which are characterized by a proper perspective of the common welfare and include effective use of funding '... to provide for the common defense' and ensure the military is ready to perform its role in foreign and domestic policy?"

PROJECT PROGRESS

It is difficult to start an analysis of the DAS because the subject is complex, and the interrelations many and varied. Group discussions lead to issues related to basic research, the industrial base, global threats, and myriad other important factors that bear on the problem. Since it was agreed that the technical process was core to the issue (Figure 1), the authors began at the core assuming: a) a requirement was established; b) resources would always be available when needed; and c) the developer served a responsive user who provided appropriate guidance.

We, the authors, were formed into a subgroup. Several of us had worked extensively in defining "what is" (reference (h)) for purposes of supporting the DSMC curriculum. Those members performed the technical process analysis leading to development of the tentative "ought to be." The subgroup developed a format which defined developer activities as the spine, and supporting activities such as the provision of resources and user guidance as parallel efforts, in the format of Figure 5. A detailed description of the Acquisition Policy "ought to be" was prepared that proposes milestone reviews as illustrated in Figure 6 and addressed in the next paragraph.

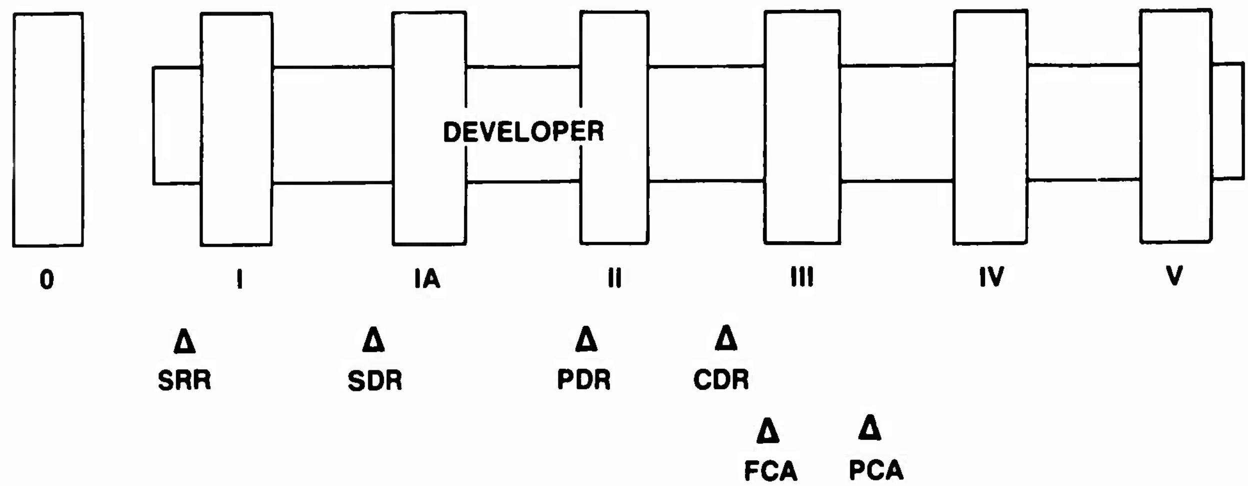
Program major reviews are realigned so as to track more closely with current systems engineering events in the case of significant developmental projects. Prior to any adjustment for individual program tailoring, the following comparison was offered:

ACQUISTION POLICY

| M/S | "Is" | Tentative "Ought to be" |
|---|---|---|
| 0 | o Mission need decision, enter CE/D. | o No Change. |
| I | o CD/V decision, sometimes after SRR. | o CD/V Decision after SRR. |
| IA | o Not Applicable. | o After SDR. |
| II | o FSD decision, generally prior to PDR. | o FSD decision, after PDR |
| IIIA | o LRIP. | o No Change |
| III | o Full Rate Production Decision. | o No Change. |
| IV* | o Logistics Readiness and Support Review. | o No Change. |

FIGURE 6

PROPOSED "AS IT SHOULD BE" MILESTONES




V* o Major Upgrade or System Replacement Decision. o No Change.

* (Reference (a) recommends combining these two reviews.)

The report concluded the following relative to the Defense Acquisition System:

- The present technical process including systems engineering is about right.

- The review and budget process should be driven by engineering progress, not by the calendar.

- Reviews can provide adequate visibility of the resource requirements needed to bridge the next review.

- Resources must be allocated and managed so as to ensure program continuity and stability.

- Program Managers should not act as proponents for their programs.

This report flowed from the following series of actions by the subgroup:

- An initial review of global and national events that impact the DAS.

- Preparation of a lengthy list of decisions related to six acquisition areas defined by CAMP. These decisions were heavily oriented to systems engineering and the currently recognized major technical reviews and audits, specifically the:

  -- System Requirements Review

  -- System Design Review

  -- Preliminary Design Review(s)

  -- Critical Design Review(s)

  -- Functional Configuration Audit

  -- Physical Configuration Audit

- Identification of the participants in some of the decisions and their roles, limiting the participants to the Developer (government and industry PM's), the User (as broadly defined earlier in this paper), Resource Controllers, and Legal advisors.

- Development of an "as it should be" systems engineering flow diagram using the disciplined language of MIL-STD 499A and 1521B.

- Translation of the preceding item into layman's terms.

- Development of preliminary conclusions.

SUMMARY AND PLANS TO COMPLETE THE PROJECT

The accomplishments of the project include:

- desired outcomes established

- application of Public Policy Analysis selected

- process model established

- technical process defined as core to the DAS

- work on technical decision process started, defining "ought to be"

- first evaluation of "is" technical process shows minimal misalignment with "ought to be"

The technical process decision description will be used to investigate the necessary interfaces with supporting activities and to propose an improved DAS process to make effective decisions in the technical process. With this core definition the project will proceed in a similar manner outward through the sphere of influence (Figure 1) to assess the entire DAS. It is expected that significant additional progress will be made by early 1990 and that current results of the project can be made available to the DSMC/NCMA Research Symposium.

REFERENCES

(a) Defense Management, National Security Review 11, Report to the President by the Secretary of Defense, June 12, 1989

(b) "Outcomes, Principles, and Criteria - A Framework for Assessing Changes to the Defense System," DSMC, January 1989

(c) "Going Technical: How to Buy Weapons the Smart Way", James E. Colvard, The Wall Street Journal, January 31, 1989

(d) System Life Cycle Technical Activities, DSMC Chart SE-T 1001 Revised February 1988

(e) Technical Management Activities, Defense Systems Acquisition Process Generic Life Cycle Representation, Federal Systems Group, Sanders Associates, Inc., 1984

(f) Systems Engineering Management Guide, DSMC, Second Edition December 1986

(g) DODD 4245.7 Transition from Development to Production

(h) Example Description of the Defense Acquisition System, DSMC, December 1988

# COMPETITON

# A-76 PRIVATIZATION INITIATIVES: AN EXAMINATION OF SMALL BUSINESS PARTICIPATION AND COMPETITIVENESS

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## ABSTRACT

This paper examines Federal privatization initiatives and more specifically, small business participation in those initiatives, that have resulted from the implementation of OMB Circular A-76 during Fiscal Years 1985-1987. The research for this study involved determining those agencies that reported A-76 cost savings to OMB for the three Fiscal Years. These included the Department of Defense and the following civilian agencies: U.S. Department of Transportation, Commerce, Energy, Treasury, Agriculture, Interior, and Health and Human Services, the General Services Administration; and the Agency for International Development.

## INTRODUCTION

Recent research conducted under contract to the U. S. Small Business Administration has provided the most comprehensive data base yet assembled on A-76 privatization initiatives occurring both within civilian as well as defense-related agencies. To build this data base, information contained within the Commercial Activities Information Service (CAMIS) of the U.S. Department of Defense as well as within the A-76 files of individual Federal civilian agencies was supplemented with information collected from agency field offices and military installations located throughout the country. Drawing from information contained within this data base, this paper has the following objectives: 1) to review briefly the status of A-76 privatization efforts for three recent Fiscal Years in terms of the number, dollars, and types of commercial activities contracted out; the cost savings effected; the location of the contracting: and the type of competition employed in the A-76 contracting out process, 2) to examine small business participation in these efforts, and 3) to explore small business competitiveness in A-76 contracting initiatives.

## STATUS OF FEDERAL AGENCY A-76 PRIVATIZATION EFFORTS

**Number and Dollar of Commercial Activities.** During Fiscal Years 1985-1987, the Federal government contracted out 793 commercial activities. Of these, 463 activities, or 58% of the total, were directly contracted and 330, or approximately 42% of the total, were contracted after undergoing cost comparison reviews. The total dollar amount of the activities contracted out was estimated to be a minimum of $1.7 billion. Contracted commercial activities resulting from cost comparisons studies acounted for over 90% of the total dollars contracted out. A-76 privatization initiatives resulted in cost savings to the government of more than $662.3 million.

The Department of Defense was responsible for almost 68% of all commercial activities contracted out. The majority, or approximately 56%, of the DoD commercial activities were contracted out through cost comparisons. Using known cost data, the Department of Defense contracted out approximately 90% of the total commercial activity dollars.

In contrast to DoD, the civilian agencies were responsible for contracting out 254 commercial activities, or slightly less than one third of all activities contracted. In contrast to DoD, where the cost comparison review was used most frequently to contract out activities, the civilian agencies contracted out 90% of their activities using direct contracts.

**Types of Commercial Activities Contracted Out.** DoD contracted out approximately 115 different types of commercial activities. The largest number of contracts awarded were for the provision of administrative support services; approximately 22% of all A-76 contracts awarded by DoD were for this purpose. Another commercial activity with a moderate number of contracts was for shelf stocking at commissary stores. Other commercial activities where more than 20 contracts each were awarded were as follows: grounds maintenance; training administration; protective coating services; air transportation services; custodial services; and food services. Food service was the activity area totalling the largest dollar volume of awards, with $209 million.

In the civilian agencies, maintenance-related commercial activities totalled the largest dollar amount contracted out, with $70.6 million and the largest number of contracts awarded. Maintenance, Food Service, and ADP Operations combined comprised 81.5% of all commercial activity dollars contracted out.

**Cost Savings.** Cost savings resulting from DoD contracting out decisions were $581.1 million or 88% of total government savings. Almost all of these savings were attributable to cost comparison studies; direct contract cost savings data were limited.

Cost savings could not be determined for many of the direct contracts from the civilian agencies. It is known, however, that the civilian agencies contributed $81.2 million to government cost savings through their contracting out activities. The Department of Transportation was responsible for 69.4% of these savings.

Location of the A-76 Contracting Out Activity. Within DoD, the Air Force was found to have awarded the largest number of commercial activities--320 awards, although the dollar amount was only 12% of the total DoD dollars awarded.

In contrast to the Air Force, the Army awarded 100 commercial activities resulting in the largest total dollar amount of $811.4 million, or 53% of the total DoD dollars awarded. The Navy awarded 78 commercial activities, the Marines, 8, and the Defense Logistics Agency (DLA), 0.

The Department of Transportation (DoT) and the General Services Administration (GSA) awarded 75% of all commercial activities contracted out by the civilian agencies. DoT contributed the highest dollar amount, $32.9 million, by contracting out 32% of all civilian agency commercial activities awarded. The next highest dollar amount was GSA for $38.3 million. The Department of Energy awarded 39 commercial activities.

Other civilian agencies were found to have contracted out small numbers of commercial activities. Health and Human Services, the Department of Commerce, and the Deparment of the Treasury each awarded six commercial activities. The Department of the Interior contracted 5 commercial activities, totalling $8.4 million. Both the Agency for International Development and the Department of Agriculture awarded contracts totalling approximately $800,000 each.

Type of Competition. Regarding the type of competition employed in A-76 contracting, preferential setasides were the most common, accounting for 440 commercial activities contracted out, 356 of which were for small business setasides. Included in these preferential setasides were 84 8(a) contracts. The National Institute for the Severely Handicapped (NISH) received approximately 22 commercial activities. The total number of unrestricted competitions employed in the contracting out of commercial activities was about 325, or 41% of the total number of commercial activities contracted out.

At least 69% of DoD A-76 direct contracting was from small business setasides. In cost comparison studies, small business setasides and 8(a) contracts accounted for 159 commercial activities contracted out. Unrestricted contracts awarded due to cost comparison decisions accounted for 45% of the total DoD cost comparison contracts.

Just over 50% of the total civilian agency A-76 commercial activities were contracted out using unrestricted contracts. Direct awards of 8(a) setasides totalled 72 commercial activities. The total of small business setasides awarded in the civilian agencies was 48 commercial activities.

## SMALL BUSINESS PARTICIPATION IN A-76 PRIVATIZATION EFFORTS

**Number and Dollars of Commercial Activity.** In Fiscal Years 1985 to 1987, small business received 552 or 70% of the 793 A-76 activities contracted out by the U.S. Department of Defense and Federal civilian agencies; they obtained $703.6 million for these contracts.

When contracts resulting from both direct and cost comparison studies are examined, it is determined that small business was more successful in obtaining contracts than dollars. Small business was awarded 65% of the total 463 direct contracts. Through direct contracts, they received, $78.8 million, or 50% of the total direct contract dollars awarded.

In formal cost comparison studies, small business won 77% of the contracts awarded; these contracts reflected 41% of the total commercial activity dollars awarded.

Approximately $601.2 million, or 85% of all A-76 dollars received by small business were awarded by the U.S. Department of Defense. DoD awarded 398 commercial activities to small business, of which 237 were awarded after cost comparison studies and 161 were directly contracted out.

Approximately 14.5%, or $102.4 million of total dollars awarded to small business, was attributed to the civilian agencies. In contrast to DoD, direct contracts reflected almost 90%, or 138 of civilian agency commercial activity contracting. Of the 154 commercial activities awarded by the civilian agencies to small business, direct contracts totalled $75.3 million and cost comparisons totalled $27.1 million.

**Types of Commercial Activities Contracted Out.** The Department of Defense contracted out under cost comparison decisions about 100 different commercial activities to small business in Fiscal Years 1985-1987. Business Services, including administrative support services, custodial services, data automation, etc., accounted for 71 of the 237 cost comparison contracts to small business. This was the largest share by one SIC code. The dollars awarded through these contracts accounted for 9.5% of the total dollars awarded to small business. Food Services totalled seven contracts whereas the dollar amount was $172.6 million, or 29% of total dollars awarded to small business.

Approximately 30 different commercial activities were awarded by the Department of Defense through direct contracts. Of the 161 direct contracts awarded to small business, 112 were classified under Business Services. Other activities included Air Transportation Services, Food Services, Refuse Collection, and Training Administration, etc. (Data was limited on dollar amounts for direct contracts in DoD.)

Data from the Civilian Agencies reveal the same type of commercial activities contracted out. The largest number of one type of activity was also Business Services, 62. The next largest group was found in SIC 17, Construction--Special Trade Contractors, including mechanical and elevator maintenance. Out of the 154 contracts awarded to small business, 46 were under this SIC classification. While Construction--Special Trade awards were 30% of the total number of contracts awarded to small business by the Federal civilian agencies, they contributed only 13% to the total dollar amount awarded to small business. Large contract awards did exist. For example, the dollar amount received for food service contracts, SIC 54, Eating and Drinking Places, reflected 24% of dollars awarded to small business, but the number of contracts involved was only 9% of the total small business contract awards.

**Cost Savings.** Small business contributed a substantial amount to government cost savings. Approximately $189.1 million was saved by the government from A-76 contracting to small business. This is underestimated because cost savings data for many of the direct contracts were unavailable.

Of the $166.2 million saved by awards to small business from the Department of Defense, $90.4 million was saved through designated small business setaside awards. Savings to the government from 8(a) contracts in the Department of Defense totalled $241,000. 18 awards directly converted to small business resulting from small business setaside and 8(a) competitions resulted in cost savings of $797,000.

A minimum of $22.15 million in cost savings can be attributable to contracting with small business by the Federal civilian agencies. This amount is considered a minimum for several reasons. First, cost savings resulting from small business food service awards in the U.S. Coast Guard could not be determined. Second, the Federal Aviation Administration was unable to provide cost savings data. Third, several agencies reported cost savings in annualized dollars. Additionally, a lack of savings was occasionally reported in direct contract activities, and even at times, negative savings were identified in direct contract activities using the noncompetitive 8(a) setaside.

**Location of the Contract Initiatives.** For Fiscal Years 1985-1987, the Air Force, Army, Navy, and Marines each contracted over 70% of cost comparison awards to small business. The highest share, 87.5%, in the Department of Defense, was awarded by the Army. The Air Force and Marines awarded the largest percentages of dollars contracted out to small business, 72% and 81.4% respectively. Small business won only 28.5% of dollars contracted through cost comparisons from the Navy and 40-45% from the Army.

Participation varied across the civilian agencies, ranging from small business capturing 100% of cost comparison dollars contracted out by the Department of Transportation to 76% from GSA to 0% from the Department of the Interior.

Recipient size of direct contracts was often unable to determine, however it is known that small business captured 65% of dollars awarded through direct contracts from the civilian agencies. Health and Human Services and the Agency for International Development awarded 100% of direct contract dollars to small business. The Treasury awarded 95% and General Services Administration awarded only 34% of their direct contracts to small business.

## SMALL BUSINESS COMPETITIVENESS IN A-76 CONTRACTING

Small business competitiveness was explored from two perspectives:

1) the abliity of small business to win A-76 cost comparison studies; and

2) the extent to which preferential setasides are used to provide assistance to small business enabling them to capture A-76 contracts.

**Small Business Ability to WIn Cost Comparison Competitions.** U.S. Department of Defense cost comparison data facilitates the most comprehensive illustration of small business's ability to win A-76 cost comparison competitions. The frequency with which small business won or lost such cost comparison competitions is outlined in Table 1.

Table 1

U.S. DEPARTMENT OF DEFENSE
IN-HOUSE AND CONTRACTED AWARDS: TOTAL, SMALL BUSINESS TOTAL AND PERCENT AWARDED TO SMALL BUSINESS BY TYPE OF COMPETITION
FISCAL YEARS 1986-1987

| TYPE OF COMPETITION | # OF COST COMPARISONS | DECISION IN-HOUSE | STATUS CONTRACT | # AWARDED SMALL BUS | % WON BY SMALL BUS |
|---|---|---|---|---|---|
| SM BUS SETASIDE | 341 | 184 | 157 | 157 | 46.0% |
| 8(a) SETASIDE | 12 | 10 | 2 | 2 | 16.7% |
| UNRESTRICTED | | | | | |
| MULTI FUNCTION | 24 | 0 | 24 | 6 | [illegible] |
| SINGLE FUNCTION | 172 | 58 | 114 | 72 | 41.8% |
| SIZE | 12 | 5 | 7 | n/a | n/a |
| TOTAL | 561 | 257 | 304 | 237 | 42.2% |

SOURCE: CAMIS Data Base
U.S. Department of Defense

Of the 341 cost comparison studies conducted using small business setaside competitions, small business won 157 or only 46% of these competitions whereas the remaining 54% stayed in-house. In 8(a) designated competitions, of the 12 cost comparison studies, only 2 were contracted out to small business. Lack of data prevented an opportunity to make observations about the ability of small firms to win cost comparison competitions in Federal civilian agencies.

**The Extent of Preferential Setasides.** Of the 552 contracts awarded to small business across both Defense and Federal civilian agencies, 440 or 80% were awarded through preferential setasides. Of the contracts awarded to small business, 90% of direct contracts and 68% of cost comparison contracts were awarded based on preferential setasides.

Table 1 further illustrates the use of the preferential setaside in DoD cost comparison contract decisions. Preferential setaside awards totalled 159 commercial activities, or 67% of the total commercial activities awarded to small business through contracting out decisions. In the Air Force, 130 of the the total 191 direct contracts awarded were through small business setasides. Approximately 91% of the Navy's direct contract awards were captured through preferential setasides.

Contributing substantially to small firm success in civilian agency A-76 contracting has been the extensive use of direct contracting, and more specifically, direct contracting coupled with the preferential setaside. The majority, or 78%, of the direct contracts awarded to small business were awarded using either the preferential 8(a) or small business setaside. At least 75% of the cost comparison awards were won through small business setaside competitions.

The true competitiveness of small business in A-76 contracting out can be witnessed through the unrestricted awards captured. Only 108, or 20%, of the small business A-76 contracts were awarded through unrestricted competitions. Thirty of these contracts were awarded by the civilian agencies; the remaining 78 by the U.S. Department of Defense.

When the Department of Defense is examined, it can be determined that small business received $279.6 million or 47% of their total dollars through unrestricted contracts. Of the 78 unrestricted awards to small business from the Department of Defense in cost comparisons, 72, or 92% were for single function contracts and 6 or 8% were multi function contracts. Single function dollar awards contributed 55% or $154.5 million to the total $279.6 million received by small business from unrestricted contracts in DoD. Multi function contracts contributed 45% or $125.1 million of total dollars captured by small business for unrestricted cost comparison competitions in the DoD. Size data were not available for many of the direct unrestricted contracts so it is impossible to draw conclusions from the limited data base.

Small business won 30 unrestricted contracts from Federal civilian agencies. A total of 28 of these were awarded via unrestricted direct contracts. Only two of these were awarded through unrestricted cost comparison competitions.

## CONCLUSIONS

Relative to other contractors, small firms have performed well in DoD and civilian agency A-76 contracting both in terms of the number of contracts received as well as the dollars obtained.

Contributing significantly to this performance has been the use primarily of the small business setaside in DoD contracting and the use of both the small business and 8(a) setaside in civilian agency A-76 contracting. Particularly in civilian agencies, the heavy use of these setasides coupled with the preponderance of direct contracting has contributed substantially to small business participation.

Data from the U.S. Department of Defense suggest that small firms have had difficulties in A-76 cost comparison competitions where the setaside was used, however. Specifically, they were found to have won slightly fewer of the total number of such competitions than they lost. A higher percentage of 8(a) competitions were lost than were small business setaside competitions, however.

The results of this study suggest that small firm participation in A-76 contracting has been heavily dependent upon preferential treatment. The true competitiveness of small business which could be witnessed through their winning of unrestricted competitions has yet to be realized. This finding has implications for future privatization initiatives, particularly if moderate and large commercial activities are channeled to the private sector. It suggests that alternatives to the setaside be identified if true efficiencies in the privatization process are to be realized while yet preserving a role for small business.

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The views expressed are those of the authors alone and do not represent the views of SBA or the Office of Advocacy.

# ACQUISITION TRENDS IN THE PRIVATE SECTOR

Major Michael E. Heberling, Air Force Institute of Technology

## ABSTRACT

Many of the emerging acquisition trends in the private sector run counter to current defense contracting practices. Since America's defense relies on the private sector, future acquisition policy needs to address the changing business environment.

In response to increased competition, a shortening of the product life cycle, and rapidly changing technology, American industry is beginning to change many of its long established acquisition practices. These changes include: supply base optimization, greater reliance on foreign sources, long term buyer-supplier relationships and a decreasing emphasis on competition in the source selection process.

Private industry is also beginning to view the entire acquisition process as a untapped opportunity for competitive advantage. By simultaneously pursuing multiple acquisition strategies, a synergistic effect results. This transforms the acquisition process from simply a cost generating function, to one that complements the strategic objectives of the firm in terms of profitability and competitiveness.

## INTRODUCTION

Future research and policy development in defense acquisition should address the changing environment in the private sector. Today, the merits of many long held commercial practices have become suspect. The following conditions are collectively serving as the catalyst for change:

- Increased competition both domestically and internationally,
- The shortening of the product life cycles, and
- The increasing cost of developing and acquiring new technology.

In response, the private sector is beginning to alter many of its traditional acquisition practices. These changes include:

- Reducing the number of suppliers (Supply Base Optimization),
- Increasing reliance on foreign sources,
- Closer, long term buyer-supplier relationships, and
- Decreasing emphasis on competition in the source selection process.

Since many of these trends run counter to current defense contracting practices, it is imperative that future acquisition policies address these changes.

## A SYNERGISTIC ACQUISITION STRATEGY

Private industry is beginning to view the acquisition process as an untapped source for competitive advantage. By pursuing many individual acquisition approaches simultaneously, a synergistic strategy results. This approach transforms the acquisition process from simply a cost generating operation, to one that complements the strategic objectives of the firm in terms of profitability and competitiveness.

Source Selection
Based On Future
Potential

Increasing Use Of Foreign Sources —> SYNERGISTIC ACQUISITION STRATEGY <— Supply Base Reduction

Closer Long Term
Buyer/Supplier
Relationships

Figure 1

The discussions that follows will focus on each of these areas separately. However, the reader should realize that it is the combination of these strategies that lead to the synergistic results.

## A CHANGE IN THE SOURCE SELECTION PROCESS

Today, the final customer demands better quality, reliability, service, and support over the life of the product. To meet these new customer requirements, firms are increasingly relying on the expertise of their suppliers for a competitive advantage. Suppliers must now enhance the strategic objectives of the buying firm.

This increased dependence on suppliers complicates the source selection process. Finding the right supplier is more difficult and the consequences of selecting the wrong supplier are more severe [1].

Unfortunately, traditional selection methods based on lowest cost rarely guarantee a world class supplier. The problem with a cost approach is that many suppliers cannot accurately forecast future costs. Bids are more likely the result of "what the suppliers think will win" [2]. Ironically, low cost is frequently:

- A reflection of suppliers that have manufacturing processes under control

- The result of joint problem solving between the buying and supplier firms.

In response to the new business environment, the criteria for source selection is shifting away from cost based competition. Increasing emphasis is placed on the following:

- Potential for a long term relationship.

- Contribution to the competitive position.

- Process flexibility - (The ability to handle a family of parts). Examples: FMS, CAD/CAM, and CIM.

- Developed quality program. Examples: statistical process control (SPC) and preventive maintenance.

- Capacity for continuous improvement in such areas as: productivity, technology innovations and cost reductions.

Note that the selection criteria is shifting. The emphasis had been based on present efficiency (cost). Now the focus is on future effectiveness or potential.

## SUPPLY BASE OPTIMIZATION

Traditionally, the accepted business practice was to develop and maintain a large supply base. Top management considered competition a healthy business practice [1]. This strategy had two advantages: 1. It reduced risk, and 2. It resulted in the lowest cost as well.

Unfortunately, these advantages are becoming questionable under the current business climate. Prompted in large part by the increasing use of Just-In-Time (JIT) manufacturing, there will be a pronounced reduction in the supply base. In this context, multiple suppliers become a disadvantage. The following issues illustrate the drawbacks of multiple suppliers:

- Contract Administration and Communication - More complicated (exp., engineering interchange, coordinating production schedules, and contract changes).

- Learning Curve Improvement - The benefits become more diluted as the number of sources increase.

- Use of Tooling and Facilities - Duplication negates economies of scale.

- Logistics - Multiple suppliers make this function more costly and complex.

By dealing with just a few stable suppliers, management can devote more of its time and resources to problem solving. This is especially important for those issues that require joint long-term solutions. To illustrate the phenomenon of supply base optimization, consider that General Motors has 3500 suppliers compared to 250 for Toyota.

## CLOSER BUYER/SUPPLIER RELATIONSHIPS

A benefit from supply base optimization is that it fosters closer relationships with the remaining suppliers. Closer buyer-seller relationships are a necessity if U.S. companies are to succeed in the global marketplace. Relationships must be long-term and offer mutual benefits to both parties [2]. These benefits include:

- Simultaneous engineering on new products,
- Quality improvement, and
- More efficient delivery arrangements.

As the number of suppliers decreases, the share of work per remaining supplier increases. In some cases, this may represent a substantial portion of the supplier's capacity. This means that the suppliers have less flexibility in taking on additional work. Consequently, before suppliers commit to any firm in a close and long term relationship, there should be a "customer selection" process. Fewer customers implies greater risk for the supplier. The future viability of supplier firms is dependent on their selecting customers that are "world class" manufacturers.

Therefore, the resulting relationships must benefit both parties. The buyer and supplier firms must share risks as well as rewards. However, both parties work toward risk minimization. They also seek methods to reduce cost and improve quality. The fundamental ingredient is that each has a commitment to the other. The livelihood of both is dependent on mutual "world class" performance. The commitment or trust necessary for a close buyer/supplier relationship can manifest itself through:

- Collaboration on production schedules,
- Technical assistance,
- Joint problem solving,
- The general sharing of information,
- Openness on the cost of operations,
- Long term contracts,
- Capital investments, and
- Installation of electronic data interchange (EDI).

There needs to be one final comment on buyer supplier relationships. The quickest way to sour the relationship is in the negotiation process. Callahan and Monczka conclude that price negotiations can have more than purely economic consequences. An economic "win" over a supplier in negotiations may mean a cooperative "loss" [3].

## INTERNATIONAL SOURCING

Global sourcing compounds the acquisition problem. It is more complicated in the following areas:

- Communication. Custom, culture, language and even time differences.
- Logistics. Distances greater, more modes of transportation, and expediting is more difficult.
- Business practices. Exchange rates, currency, tariffs, duties, letters of credit, countertrade, quotas, and the negotiation process.

Yet, in spite of these formidable obstacles, there is an increasing reliance on international sources. At the national level, roughly 75% of the firms are using international sources. There are numerous reasons for this trend. However, the most significant is the intense foreign competition. With over 85% of the U.S. industries facing foreign competition [4], many firms are now re-examining their domestic sourcing arrangements.

To counter the inroads of foreign competition, American firms are adopting a global perspective in all of their operations. This includes foreign markets as well foreign sources of supply. The decision to seek foreign sources is not taken lightly. It is a strategic decision. Firms will not seek foreign suppliers unless they will improve a firm's competitive position. The same issues previously discussed under source selection remain relevant in foreign sourcing.

The issue of low labor rates in foreign countries is overblown. Even for the average American manufacturer, labor makes up only 21% of the total cost for operations. The real cost drivers are materials, supplies, and equipment which make up 63% of the total cost [5].

While price is the most frequently cited reason for seeking foreign sources [6], this involves more than just low labor rates. It is a function of stable manufacturing processes, innovative technology, and a philosophy of continual improvement.

Barring protectionist legislation, we can expect more foreign sourcing in the future. The following conditions foster this trend:

- Tariff reductions,
- Lower shipping costs,

- More efficient international communication links,

- Changing political attitudes [4], and

- Emerging technological and manufacturing capabilities in third world countries.

## SUMMARY

Due to intense competition, American firms are beginning to change their acquisition practices. The most obvious change is the reduction in the number of suppliers. Those that remain must be "world class" in terms of flexibility, technology, innovation, expertise, and management. The criteria for selection will be based on cooperation, commitment, and potential to provide a competitive edge. These suppliers will be sought worldwide.

Since America's defense relies on the private sector, future acquisition policy should reflect these changing business practices.

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## COMPETING EMPHASIZING QUALITY

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### ABSTRACT

This research reports the results of a study of the defense procurement process which compared approaches to obtaining quality materials in the Navy and the commercial/industrial environment.

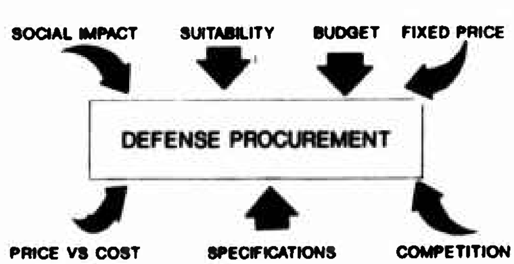
Using the framework suggested by David Garvin (1) the concept of quality is broken into characteristics or components, thereby providing a framework to define quality and a basis to develop objective quality criteria.

The results showed potential for practical application of an objective measurement system using performance, reliability, maintainability, durability, proven reputation, warranty and effective scheduling in the source selection process.

The study also corroborated a widespread belief that competition in defense acquisition is based primarily on price because it is the only measurable variable available.

### INTRODUCTION

The policies, pressures and practices surrounding government purchasing places the defense source selection process in the environment illustrated in Figure 1.




Individual source selections must be made fairly and openly with each being defensibly based upon a legal and technical criteria which can be demonstrated to auditors, unsuccessful bidders and other interested parties.

The research effort briefly described in this paper focused on identifying, ranking, and evaluating quality factors which could be acceptable and useful to the defense contracting officer in making source selections within the unique environment of defense acquisition.

It was apparent that the theoretical foundation for objective quality measurement is not well enough established to permit evaluation of quality factors in either the government or commercial/industrial environments. The principle authors in the field of quality: Crosby, Juran and Deming fail to provide objective methods of obtaining quality purchases. (2)

The current conventional wisdom in obtaining quality is to work towards the development of long term symbionic relationships with suppliers.(3) Such relationships are nearly impossible to attain under the current environment of government rules and practice.

There is a need for a method to quantify evaluation of factors in addition to price. This research effort concentrated on quality factors through an adaption of the dimensions of quality framework established by David Garvin. By segmenting quality into dimensions which could be weighted, ranked and evaluated, a quantifiable, auditable and defensible means could be developed for the defense contracting officer's use when evaluating source selections.

The research was focused in four areas. First, to identify a method of quality evaluation which was practical for most defense contracting applications. Second, to explore the acceptance of such a method by asking a broad range of Navy and commercial/industrial purchasing officials to determine its acceptability.

Third, to look at these populations of purchasing officials to determine if there were differences in how they currently approach purchasing decisions in the areas of quality and price. Fourth, to place the method of identifying, ranking and evaluating within the defense purchase environment so that it could be viewed within the context of many additional policy and practical pressures.

The research instrument was primarily a broadly based questionnaire survey to a representative sample of Navy contracting officers and a random sample of the National Association of Purchasing Management membership (NAPM). A separate but similar survey of designated Navy program managers was designed to gain their perspective of the usefulness of the proposed measures and the line user's view of the effectiveness of the current procedures as they balance price and quality.

The data collected from the questionnaires was analyzed using a variety of statistical, graphic, non-parametric, and exploratory data analysis methods. After this analysis was applied to seven proposed hypotheses, it became apparent that there is a significant difference in the approach to purchasing quality goods and services between the Navy and commercial/industrial firms. It is equally clear that there is motivation on the part of defense contracting officers to move towards a system which places increased emphasis on quality while still reflecting the importance of price. The challenge is to develop an objective quality system which can effectively operate in the defense acquisition environment.

## THE RESEARCH QUESTION

The research question was framed as follows:

How can objective quality criteria be identified, ranked and evaluated for potential use in competitive Navy procurement source selection?

Its answer is in three parts. First, six objective quality criteria were identified by adapting Garvin's concept of breaking quality into its component dimensions appropriate to the Navy's acquisition environment.

Second, these six dimensions were consistently ranked by Navy program managers and contracting officers using both value and ranking criteria. They are defined and listed below in order of their relative ranking.

**Performance** refers to the operating characteristics of the item to include other technical characteristics which supplement a product's basic functioning.

**Reliability** reflects the probability of a product failing within a specific period of time.

**Maintainability** which is the speed, accessibility and ease of repairing an item.

**Durability** measures the use available from the product before it deteriorates.

**Proven Reputation**, which will be established through successful completion of contracts for the same or similar items.

**Warranty**, which signifies the willingness of the vendor to have delivered products evaluated against preestablished standards.

While not expressly defined as a dimension of quality a seventh quality factor **schedule** was identified as an important element in obtaining quality.

Third, the research effort demonstrated the willingness of Navy program managers and contracting officers to place a value on these dimensions in an unconstrained budget environment. As shown in Table 1 each of the groups were willing to place a price premium in the range of five to ten percent for a ten percent improvement in the quality factor being considered.

TABLE 1
MEANS OF QUALITY FACTOR EVALUATION BY GROUP POPULATION

| QUALITY FACTOR | NAVY CO | NAPM | NAVY PM |
|---|---|---|---|
| RELIABILITY | 10.2 | 8.3 | 12.8 |
| PERFORMANCE | 9.6 | 8.1 | 10.2 |
| DURABILITY | 7.2 | 6.7 | 8.0 |
| SCHEDULE | 7.3 | 6.6 | 7.2 |
| MAINTAINABILITY | 7.9 | 6.3 | 9.5 |
| PAST PERFORMANCE | 6.1 | 6.5 | 9.4 |
| WARRANTY | 5.2 | 4.6 | 6.0 |

A review of the regulatory and policy directives established no specific prohibition to the use of such quality criteria. The FAR specifically states that source selections are to be made based on price and other factors.(4) Therefore, if there is no prohibition and the target populations are disposed to use them, why are such quality measures not in use? Comparison of the commercial and military purchase environments provides part of the answer. The acquisition environment described in illustrated in Figure 1 discourages the development of long term cooperative partnerships with suppliers. Such partnerships are advocated by the major authors and were reported as the prevalent practice by this research. There is a lack of a theoretical base from writers in the field for an accepted measurable commercial quality criteria. In addition any system requiring information can only be as good as the information it is fed and the problems associated with quality feedback in defense contribute to the need not only for the approach suggested but improvements in quality data feedback.

The establishment of the quality criteria proposed should not be locked into specific measures but rather provide a menu which will permit adaption to the particular requirement.

## THE SUPPORTED HYPOTHESES

The results of the survey comparisons (5) can be summarized as following relationships:

> Competition is viewed as positively influencing the quality of products obtained unless the competition is dominated by price considerations.
>
> Price competition is a more significant factor in Navy contracts than it is in commercial purchases.
>
> The effectiveness of the Navy purchase process in obtaining quality products is inadequate. This results from the over-emphasis on price and the poor feedback of accurate and timely information to the Navy contracting officer.
>
> Quality measures based upon the dimensions of quality framework provide an approach to balance price with other important aspects of the purchase decision.

## APPLICATION OF THE CONCEPT

Within the current method of minimum specification satisfaction there is little impetus for a contractor to innovate or exceed the minimum. The incentive is to reduce price with the minimum effort required to satisfy the specification. This results in a practice which loses more than its price saving.(6) Such a focus on low price makes the rules of competition easy to apply focusing principally on price with results such as those reported in the Washington Post:

> The Defense Department inspector general's office, testing random samples of parts bought by the Air Force the past two years, estimated that as much as 98 percent of the money spent for the spare parts surveyed went for items with major or minor defects.(7)

To shift this emphasis from price competition, it is important that the vendor recognize that something more than price will go into the source selection and that there will be an incentive provided to a contractor who can provide a better product at a higher price.

Immediately this can raise the specter of 'gold plating' and too much subjective judgement. However, discussions with senior contracting officials confirmed that, provided the relationship was clearly stated in the solicitation and applicable to all vendors, there is no impediment to its adoption. The following examples illustrate the concept.

## PERFORMANCE QUALITY FACTOR

An aircraft is given a 'stretch goal' of reducing weight of installed equipment. Assuming that the current standard communications radio weighs 10 pounds and costs $100. There is some value to the program for a reduction in its weight. The current contract method would specify 10 pounds or some lighter weight. Contractors would then seek to minimize costs to meet that specification perhaps ignoring weight savings which might cost 'a little more.' Simplistically the proposed quality factors contract would be structured as follows:

## QUALITY FACTORS CONTRACT SPECIFICATION

> All other performance specifications are unchanged. An incentive of 10 percent of total price for each pound less than 10.

Assuming that three bids are received which satisfy all the specifications as follows:

| | Company A | Company B | Company C |
|---|---|---|---|
| Weight | 10 | 8 | 6 |
| Price | $100 | $115 | $150 |

Selection would be for Company B, because its price is within the range specified for the incentive. The product proposed by company C would not be selected because the preestablished weight/price relationship is exceeded.

## GENERALIZED APPROACH

From the example discussed, the contract proposal process has become much more complicated for the supplier. No longer will attainment of the minimum specification be sufficient. A product which exceeds the specification in a quality factor considered valuable to the requestor may be selected over one which meets the specification. The example cited is simplistic but not impractical for application. Of course there is the potential of adding so many incentive systems that the process would become one of linear programming, but even in this case the evaluation of the criteria would be based objectively. It provides a means to change the focus from lowest price to one of best value.

One of the major distinctions between the government and commercial purchasing practice is that this relationship must be clearly stated in the request for bids. Because of the absolute requirement for fairness, all interested parties will need to understand the relationships proposed and the evaluation criteria.

There is precedence for such systems. The source selection technique for major military systems employs elements of it in the evaluation of technical proposals. In the commercial environment the focus has been on supplier evaluation systems. The 'Blue Ribbon Supplier' systems being established in the services and DLA recognize a supplier's past performance with a percentage cost preference in subsequent source selections.

## CONCLUSION

The research effort focused on identification of a feasible way to encourage a quality dimension in the competition for government acquisitions. By applying objective quality measures, it may be possible to shift the emphasis away from price competition as suggested by the Packard Commission.

> Commercial procurement competition simultaneously pursues several related objectives: attracting the best qualified suppliers, validating product performance and quality, and securing the best price...Defense procurement tends to concentrate heavily on selecting the lowest price offer, but all too often poorly serves or even ignores other important objectives. (8)

Adaption and application of the quality measures suggested by this research is not a panacea. Environmental peculiarities of defense contracting make implementation a complex undertaking. In particular two are most troublesome: the pressure of price as the dominant variable and the poor feedback of information.

The background factors behind the price pressure include: annual budgeting, cost versus price and satisficing. The use of an incentive or variable quality factor specification would only provide a tool for the requesting activity to fund improvements where they believe the returns justify such expenditures. If the current specification provides an item which is fully satisfactory, there is no need to use the method. As such, there must be a cost-benefit relationship clearly established in the judgement of the requiring activity that the better performance, durability, etc justifies the increased expense.

One of the clearest findings of the research is that the current method of quality control and information feedback is not working adequately. It is here that efforts to improve defense acquisition must become focused. Research into methods of providing timely and accurate product performance information to the contracting officer in a format which can be used would be of great value.

Identifying, ranking and evaluating quality factors proposes an improvement on the margin which could provide activities, program managers, and contracting officers a means of considering various dimensions of quality in their source planning. Such an approach would encourage American industry to compete for new contracts with the recognition that price and other factors such as performance, reliability, maintainability, durability, warranty and schedule will be combined and objectively evaluated in making purchases.

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COMPETITION DURING DEVELOPMENT

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ABSTRACT

This paper presents the initial results of an Internal Research and Development (IRAD) study undertaken by The Analytic Sciences Corporation (TASC) to determine the effects of competition during development on the production of major weapons systems. Prototype competition, advanced development competition, and competitive fly-offs of alternative systems were examined.

Although there is limited historical experience in the use of development competition in major weapon system procurement, this study did identify evidence of a reduction in production unit cost growth, and/or increases in quality, producibility, and contractor responsiveness for programs using development competition. The extent of these effects depended upon the selection criteria used during the contractor selection process. Thus, the use of competition during development was found to motivate the contractor to respond to the objectives that appeared important to the government. This indicated that a successful development competition must begin with a clear identification of the government's priorities.

## INTRODUCTION

### BACKGROUND

Competitive procurement of defense goods and services long has been a stated objective of the Congress and the Department of Defense (DoD). Benefits that have been attributed to competition include reduced and controlled costs, improved performance, enhanced industrial base, reduced risk, and improved quality. The potential benefits of competition have led to increased interest in the use of competition to reduce and control weapon system costs. For example, the Competition in Contracting Act of 1984 (CICA) mandated the use of effective competition throughout the weapon system acquisition cycle, except in extremely limited circumstances. The use of effective competition in this context encompasses both sealed bids and competitively negotiated procurements.

Much of the recent emphasis on increased competition has concentrated on the use of competition during production to reduce weapon system costs. Increasingly, the other hypothesized benefits of competition, improved quality and reliability, enhanced delivery, reduced risk, improved performance and controlled cost, have become objectives of weapon system competition. Attainment of these objectives may require that competition begin prior to the production phase. This paper concentrates on the use of competition during development to attain key program goals.

Competition during development may involve competitive system validation or competitive Full Scale Development (FSD). Competition during system validation, or competitive prototyping, is a strategy in which two or more competing designs of a future weapon system are funded through a prototype stage. Source selection then is based upon the demonstrated performance of the competing prototypes with regards to technical achievements, cost, producibility, and logistic support.

Competing firms also may be maintained through FSD; however, few programs have undertaken this approach due to the high initial investment associated with funding two firms in FSD. Recent programs which involved competitive FSD include the Air Launched Cruise Missile, the Division Air Defense Gun, and the UH-60A Helicopter. Under both competitive strategies, the actual performance of the systems is a major factor in the decision of which contractor will continue with subsequent phases of the acquisition. An overview of competitive development is provided in Figure 1.

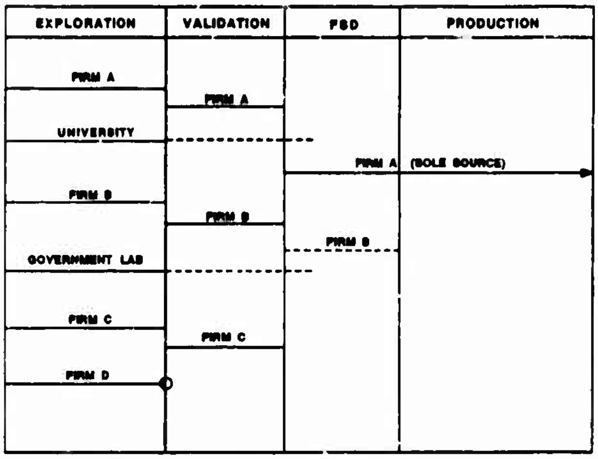


Figure 1 Development Competition

This paper discusses the use of competition during the development of a weapon system program. The results of recent programs are summarized as well as several key factors associated with successfully implementing development competition. Specifically, this paper presents a theoretical discussion of the benefits of competition during development, a summary of previous studies on this subject, the results of TASC's recent analysis, and our thoughts on the future.

PREVIOUS RESEARCH ON PRODUCTION COMPETITION

Analyses of shifts and rotations incorporate the assumption of perfect insight and are used as a baseline. Relaxing the assumption results in altering the shift and rotation. Extensive sensitivity analysis is conducted based on relaxed assumptions reflecting imperfect knowledge on the part of the system developer.

## THEORY OF DEVELOPMENT COMPETITION

The hypothetical costs and benefits attributed to the use of competition during development include both price and non-price considerations and differ between development and production.

### BENEFITS DURING THE DEVELOPMENT PHASE

Some recurring concerns in weapon system development are the continuing escalation of program costs over original estimates, lengthened schedules, and greater technical risk due to changing specifications. One of the often-hypothesized benefits of development competition during the development phase is enhanced cost control, or cost growth avoidance. The competitive nature during the development effort is expected to incentivize contractors to control cost through reductions in the program's technical risk and maintenance of schedule requirements. It is also hypothesized that the overall technical design will meet or exceed original specifications given the competition between designs for FSD

### BENEFITS IN PRODUCTION AND BEYOND

The major problems found in the weapon system production and operations phases are increasing costs, poor manufacturing designs and unacceptable field performance weapon system reliability due to an inadequate technical design. It is hypothesized that because competition during development can result in the selection of a single design for production, developers are incentivized to provide a design suited to production with increased field performance and reliability. It has also been hypothesized that development competition reduces production costs through a reduced $T_1$ going into first lot production as depicted in Figure 2.

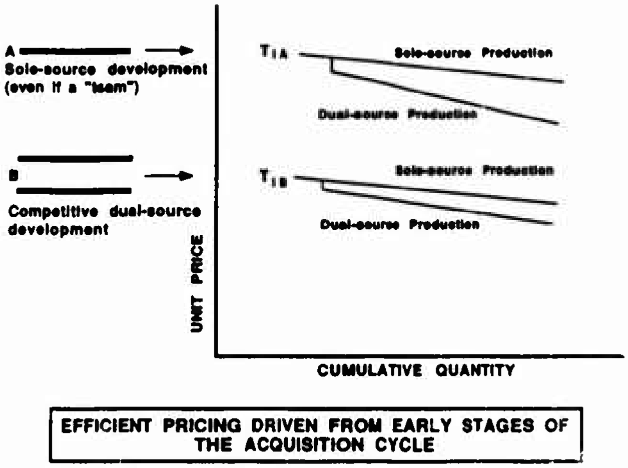


Figure 2 The Impact of Development Competition on Production

### THE COSTS OF COMPETITIVE DEVELOPMENT

Development competition can affect system acquisition costs from the demonstration and validation phase through the production and the operation and support phases. Initially, costs may be higher than in a comparable single-source program, since it is necessary to fund two or more competitors' development efforts until their systems have been evaluated and a down selection point has been reached. Historically, the cost of the prototyping phase has varied from 7 to 20 percent of total acquisition costs.

The costs of competitive development often have been mistakenly assumed to be twice the cost of a comparable single source effort. This assumption is predicated on the duplication of the entire development effort; however, it ignores the logical program restructuring that would occur to incorporate multiple contractors. For example, a single source development effort may involve the fabrication and test of 10 development units. In a competitive development, the test program may require an additional 5 test articles for a total of 15 rather than 20. Similarly, additional government management personnel may be required to direct 2 development contractors, however these personnel will not represent a duplication of the entire program office.

The most obvious costs associated with competitive development include the following:

- Redundant engineering and design efforts
- Additional test articles and test support
- Duplicative production planning
- Redundant contractor management
- Additional program office management.

The extent to which these costs outweigh the benefits of development competition is often cited with little supporting documentation. Quantifying these costs is necessary in order to compare the benefits of development competition to its costs.

## PRIOR DEVELOPMENT COMPETITION STUDIES

Few research efforts have assessed the programmatic impact of competitive development. Empirical research conducted by Rand also has indicated that competitive prototype programs have experienced generally lower total program cost growth than single source programs.[1] Figure 3 presents the annual cost growth trends for SAR-level programs that involved competitive prototyping and single source development programs. The average annual growth for single source programs is 5.6 percent, while the average annual growth for the competitive prototype programs is 2.4 percent.

Cost growth for competitive development has been less in both FSD and procurement. A recent review of total program cost growth during FSD has indicated that programs with competitive FSD phases have incurred an average cost growth of 2 percent while comparable single source

[1] "Factors Affecting the Use of Competition in Weapon System Acquisition," RAND Report R-2706, February 1981

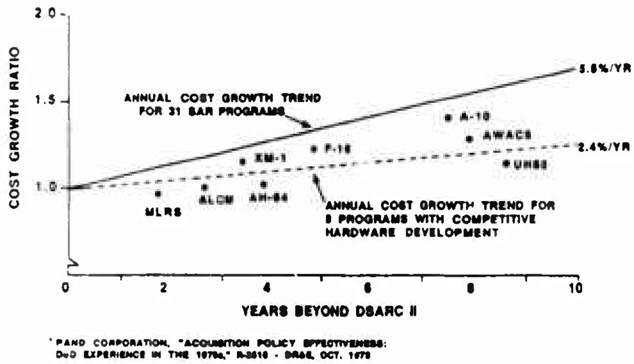


Figure 3 Impact of Development Competitive on Cost Growth

efforts have incurred cost growth of over 40 percent.[2] The percentage cost growths exclude inflation and growth due to quantity changes. The small sample size of 3 competitive FSD programs does not allow statistical analyses. The results do suggest that competitive FSD results in enhanced cost control.

The Institute for Defense Analysis (IDA) compiled a data set of 14 competitive (development/design) and 27 noncompetitive programs using 1982 SAR data.[3] The average annual IPC growth rate was estimated at 3.1 percent for the competitive programs and 5.8 percent for the noncompetitive sample. The IDA paper experiments with adjustments to the data set in order to circumvent extreme sample values, as well as other problems which emerge from any data analysis. The largest problem which emerges from the analysis is the low confidence levels of the estimates arising from relatively low sample sizes and wide variability in the data. Table 1 summarizes the IDA report.

Several hazards exist in aggregate data analysis of this type. Problems include:

- Design Changes
- Quantity requirement changes
- Small sample size (especially competitive)
- Wide variability in cost data
- Inconsistent use of DTC goals.

Comparison of production cost growth rates suggest that development competition may help control production cost growth. Small sample sizes, wide variability of the data, and program specific characteristics, prevent a more accurate measure using this type of analysis.

The Analytic Sciences Corporation (TASC) has recently prepared a report which details several aspects of some recent competitive development efforts. Building upon the previous research efforts, the TASC effort has examined both the aggregate and programmatic impacts of competitive development. The results are discussed in the following chapters.

Table 1 Cases from SAR Analysis

| PROGRAMS WITH R&D PROTOTYPE COMPETITION | | PROGRAMS WITHOUT R&D PROTOTYPE COMPETITION | | | |
|---|---|---|---|---|---|
| PROGRAM | ANNUAL PERCENT CHANGE* | PROGRAM | ANNUAL PERCENT CHANGE* | PROGRAM | ANNUAL PERCENT CHANGE* |
| MLRS | -2.3 | Sidewinder | -1.5 | Stinger | 6.4 |
| DIVAD | -0.3 | AV8B | -0.5 | HARPOON | 6.4 |
| F/A-18 | 1.5 | NAVSTAR | 0.4 | FFG-7 | 7.5 |
| AN/TTC-39 | 1.8 | Trident Missile | 0.7 | DSCS 3 | 7.7 |
| UH-60A | 2.0 | SSN688 | 0.8 | TACTAS | 9.1 |
| SLCM | 2.2 | CG-47 | 1.4 | HARM | 9.9 |
| E-3A | 2.8 | F-15 | 2.6 | Patriot | 10.2 |
| F-16 | 3.4 | Trident Submarine | 2.8 | LAMPS Acft | 11.8 |
| M-1 | 5.7 | F-14A | 2.9 | EF-111A | 13.6 |
| Hellfire | 7.1 | IR Maverick | 3.3 | Bradley FVS | 13.6 |
| ALCM | 8.5 | CH-47D | 3.5 | Pershing 2 | 22.2 |
| AH-64 | 9.9 | CH-53E | 4.3 | LAMPS Ship | 22.4 |
| GLCM | 15.3 | Pheonix | 5.1 | CAPTOR | 25.8 |
| Copperhead | 66.0 | Sparrow | 5.8 | | |

*Average annual percentage change in constant-dollar unit procurement cost (UPC) from time of development estimate (DE) until December 1982. Based on information in Selected Acquisition Report, December 1982.

RECENT PROGRAMS

As use of development competition increases over time, useful insight and lessons learned should add to the knowledge base for this type of competition. Already with limited applications of development competition, significant lessons learned have accumulated. Case histories which presently yield some significant insight include:

- SINCGARS-V
- MLRS
- AH-64
- ALCM.

SINCGARS

The Single Channel Ground and Airborne Radio System (SINCGARS-V) is the VHF-FM radio communications system providing the primary means of command and control for infantry, artillery, and armor units. The SINCGARS program is summarized in Figure 4.

- COMPETITION HISTORY
  - THREE CONTRACTORS DURING VALIDATION EFFORTS
  - TWO FIRMS PROCEEDED INTO ADVANCED DEVELOPMENT - ITT, CINN ELEC
  - ITT WON PRODUCTION AWARD, WITH FOUR FULLY PRICED OPTIONS
- INITIAL DTUPC GOALS ABANDONED
  - EARLY TECHNICAL CHANGES, ENHANCEMENTS INCREASED SYSTEM COSTS
  - EXPECTED UNIT COST GREW APPROX 300%
  - COMPETITION FOR PRODUCTION AWARD HELPED CONTROL COST GROWTH
- RELIABILITY PROBLEMS
  - PRODUCTION SCHEDULE HAS SLIPPED 2 YEARS
  - ITT ABSORBED SIGNIFICANT OVERRUN - APPROX $30 MILLION

Figure 4 SINCGARS Competition Summary

The SINCGARS validation efforts began in April 1978, with three firms under contract to build prototypes. ITT Corporation (Aerospace/Optical Div) and Cincinnati Electronics Corporation were contracted to develop the slow frequency hopping concept (SFH), while Rockwell Collins was to develop the fast frequency hopping (FFH) technique. Rockwell was dropped in January 1982 because

[2] Kratz, Lou and Larry Cox, "Competition of Defense Procurements: Evidence, Theory, and Application," The 1982 Federal Acquisition Research Symposium, Washington, DC, May 1982

[3] "Competition as an Acquisition Strategy: Impact of Competitive Research and Development on Procurement Costs," James P. Bell, Institute for Defense Analysis, IDA paper P-1744, November, 1983

their design offered a much higher technological risk than the other two efforts. The two remaining contractors, ITT and Cincinnati Electronics, received engineering development contracts, in parallel, with the advanced development efforts already underway. A production contract award was planned for FY83.

During December 1983, ITT was awarded a single year production contract, with four option years. The contract was Firm Fixed Price with economic price adjustment (FFP/A). Although both contractors had technologically acceptable designs, ITT's design was further along and presented less risk for production. Production costs were the deciding factor. Before the third option was awarded, reliability problems arose during First Article Testing. The awarding of the final two options was suspended while ITT solved the problems. After ITT had spent considerable internal funds improving reliability, the production contract was re-baselined for award of the final two option years during FY88.

During validation, when the Army was primarily concerned with technological factors, the projected unit production costs grew. The initial DTUPC goals were abandoned. The configuration was upgraded and system capabilities were expanded. Once the two remaining producers proceeded into advanced development, cost became the overriding factor and projected production costs have remained under control. Also, with the presence of another contractor (during AD), the winning firm was willing to accept a cost ceiling which, given the eventual reliability problems, resulted in substantial savings to the Army. Table 2 illustrates the changes in SINCGARS unit production cost.

TABLE 2 SINCGARS-V Production Cost (FY84)

| Calendar Year | Unit Cost |
|---|---|
| 1978 | $ 3,702 (Goal) |
| 1982 | $ 12 768 (Goal) |
| 1984 | $ 8,751 (Actual) |

MULTIPLE LAUNCH ROCKET SYSTEMS

The Multiple Launched Rocket System (MLRS) was designed to supplement cannon weapons by delivering a large volume of fire power in a short time. The MLRS, with a dual-purpose improved conventional submunition warhead, will provide an all-weather, in-direct fire capability to attack the enemy's indirect fire weapons, air defense systems, and light material and personnel targets, especially during surge conditions.

The technology for the system was well established prior to program validation. Significant amounts of the technology were previously applied. New development areas were kept simple. The MLRS program is summarized in Figure 5.

The acquisition strategy involved two contractors, Boeing Aerospace Co. and Vought Corporation, in a competitive validation. The winner of the competition could receive single source contracts for the $3.5 billion planned production program. The winner would proceed into a qualification phase, during which a multiyear bid for production would be submitted. If the multiyear bid held close to the projected prices which were proposed during the competitive validation, then the government planned to award the multiyear. If the government felt the production bid was high, then they planned to establish a second production source.

Both contractors were responsive to the program office requirements. The primary source selection criteria was cost effectiveness. The contractors concentrated on cost and performance. Both contractors reduced projected production costs by approximately 25 percent during the competition. Vought Corporation won the competition and proceeded into the qualification phase. Vought eventually was awarded a multiyear production contract as they reduced their planned production costs an additional 2 percent during the multiyear bid.

- **COMPETITION HISTORY**
  - **-- TWO CONTRACTORS IN VALIDATION - BOEING, VOUGHT**
  - **-- SINGLE SOURCE FOR REMAINDER OF PROGRAM**
  - **-- ARMY KEPT OPTION FOR SECOND PRODUCTION SOURCE**
- **AGGRESSIVE CONTRACTOR PERFORMANCE DURING COMPETITION**
  - **-- LARGE PRIZE - $3 1/2 BILLION PRODUCTION RUN**
  - **-- BOTH FIRMS ACCEPTED CONTRACT CEILINGS**
  - **-- VOUGHT INVESTED OVER $50 MILLION IN PLANT & EQUIPMENT**
- **PRODUCTION UNIT COST BELOW DTUPC**
  - **-- BOTH FIRMS BID MUTUALLY LOW**
  - **-- INDEPENDENT STUDY VALIDATED ESTIMATES**
  - **-- MULTI-YEAR CONTRACT - WITH THREAT OF SECOND SOURCE**
- **STABLE CONFIGURATION**
  - **-- SIMPLE DESIGN**
  - **-- MUCH PREVIOUSLY APPLIED TECHNOLOGY**

Figure 5 MLRS Competition Summary

The program office noted that both contractors were highly motivated by the large production program. Beneficial actions cited by the program office included:

- Creation of separate divisions to offload high corporate overhead
- Locate plants in low-cost labor areas
- Co-locate with subcontractors to reduce transportation costs
- Automate production systems
- Substantial corporate investment
- Deferred methods of amortizing investments
- Negotiated Fixed Price contracts with subcontractors
- Agreed to low profit percentage and FPI contracts with low price ceilings
- Accepted ceilings on development contracts

Although the MLRS represents a relatively simple development effort, the acquisition program includes key features which emerge as important to a successful implementation of development competition. These features include:

- Emphasis on producibility
- Reward for winning is substantial
- Cost effectiveness is primary selection criteria

AH-64 APACHE ATTACK HELICOPTER

The AH-64 carries the laser guided Hellfire antitank missile as well as a 30mm Chain Gun and 2.75 inch rockets for suppressive fire. The AH-64 features a sophisticated target acquisition/designated sight (TADS) including a laser range finder as well as a television camera and a forward-looking infrared (FLIR) system for night vision. A pilot night vision sensor (PNVS) also is included for accomplishing several maneuvers.

Hughes and Bell competed in a 36-month engineering development Phase One effort; the winner of the competitive phase (which included a fly-off) was to proceed into a single-source FSD effort. Phase One was an engineering development of the air vehicle but it did not include integration of the mission subsystem. The Apache program is summarized in Figure 6.

Cost and performance received equal weight as a selection criteria. A ceiling of $1.6 million (FY72 dollars) for unit production was enforced by the program office. Proposals with unit costs exceeding the $1.6 million figure were considered nonresponsive. Unit production cost goals for the program and the contractors ranged from $1.1 to $1.4 million dollars.

Hughes won the competition. Since both firms went to ceiling on costs, the selection was made on the basis of performance and producibility considerations.

During the single source Phase Two effort, several problems arose. A change in requirements led to significant

- COMPETITION HISTORY
  - -- FIVE CONTRACTORS DURING VALIDATION
  - -- TWO FIRMS SELECTED FOR PROTOTYPING - HUGHES, BELL
  - -- HUGHES WON FLY-OFF, PROCEEDED INTO FSD
  - -- HUGHES - SINGLE SOURCE PRODUCTION
- COST GROWTH THROUGHOUT PROGRAM
  - -- PROTOTYPING EXPERIENCED 40% COST GROWTH FROM BOTH FIRMS
  - -- PRODUCTION UNIT COSTS HAVE INCREASED APPROX 80%
- SIGNIFICANT TECHNICAL CHANGES IN FSD
  - -- SWITCHED FROM TOW TO HELLFIRE MISSILES
  - -- REQUIRED DEVELOPMENT OF TADS/PNVS - DUAL SOURCED

Figure 6 Apache Competition Summary

integration problems. Also, with contracting now on a single source basis most competitive pressure on costs had been removed (subsystem competitive development effort for a new TADS/PMS system was enacted, but produced questionable cost savings). After the single source Phase Two effort, unit production cost had grown to almost $4 million.

Examination of the case studies revealed specific examples of procurement cost savings attributable to development competition. These examples include:

- Major design innovations reduced cost and improved performance
- Costly design features were avoided without degrading system capabilities
- Cost/Performance tradeoffs eliminated certain capabilities that the contractors found (with government encouragement) to be too costly in light of service priorities and design-to-cost (DTC) goals
- Producibility changes to designs and production methods had important cost-reducing impacts.

AIR LAUNCHED CRUISE MISSILE (ALCM)

The ALCM program arose from an FSED competition which was conducted by the Joint Cruise Missiles Project Office. The competition matched the Boeing ALCM vs the General Dynamics SLCM, with Boeing eventually winning the production award. The objectives of the competition included cost and schedule control. The competition featured a pilot production and fully integrated launch from the B-52.

Another example of a competitively developed program (during FSD) to reduce production costs is the ALCM. When the ALCM went into production, Boeing attained the first unit goal of 5669 labor hours. The program office projected a labor hour cost improvement rate of 0.85; however, Boeing realized a 0.65 cost improvement rate for the initial production lots, as depicted in Figure 7. This significant reduction was attributed to Boeing's "Curvebuster Program" in which cost-reducing measures were implemented throughout the facility to enhance Boeing's ability to attain their competitive production bid. As a result, the average unit cost of the initial lots was 20 to 30 percent less than originally estimated.

A major objective of the ALCM competition was to control unit production costs. Firm bids on pre-priced production lots were required. Several cost reducing design changes resulted from the competition. The competition was introduced after the two competing designs were relatively firm, allowing the competitors to concentrate on reducing unit production costs.

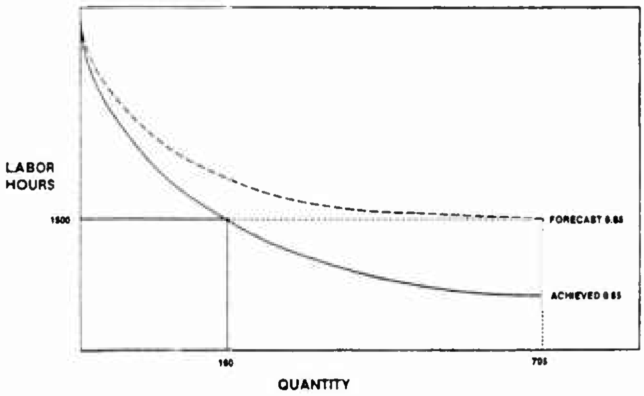


Figure 7 ALCM Manufacturing Labor Curve

SUMMARY

With the defense environment entering a period of budget austerity, policymakers must not lose focus on the benefits of dual source/competitive development efforts. Evidence indicates that the initial costs and risks of a dual source development effort are often rewarded by a successful long-term program. If (program) management's objectives (e.g., production cost ceilings, performance requirements, life-cycle cost goals, schedule constraints) are achieved, then the initial risk of a competitive development was worth the upfront investment.

A comprehensive cost-benefit approach is clearly required. The initial costs, risk, and administration requirements of conducting a dual source development must be evaluated against the future rewards of a successful competitive effort. These future rewards are not only defined on a programmatic basis, but are determined by program management when the competition is structured. Potential rewards which may be evaluated during a cost-benefit analysis include:

- Production Cost Savings
- Schedule Maintenance
- Support Cost Savings
- Performance and Quality Improvements
- Industrial Base Considerations.

Research at TASC has concentrated on building an effective cost/benefit methodology. The initial effort consisted of both a compilation and examination of a comprehensive data base. The collection of data is ongoing. Currently, relationships are being identified, quantified, and coded into a cost-benefit model. The TASC effort will ultimately provide programs with a methodology that will help determine the likelihood of success for alternative development competition strategies.

Difficult and challenging decisions lie ahead if the services are to increase the use of development competition. Policymakers must recognize the significant future rewards in order to allow the necessary upfront funding. The services must accurately define long-term objectives when deciding on whether to use development competition. Program management must structure the competition in a manner that drives the contractors to the desired goals.

As the frequency and use of development competition increases, important lessons learned must help provide a path for future programs in this area.

# DUAL SOURCING IN AIRCRAFT ENGINE PRODUCTION

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## ABSTRACT

The Defense Acquisition Improvement Program (the Carlucci Initiatives), instituted in 1981, includes an initiative to increase competition in the acquisition process. In this paper, we focus on competition as dual sourcing in the production of a major weapon subsystem, aircraft turbine engines. This study shows results from two engine competitions -- the the Air Force's alternative fighter engine program and the Navy's F404 program. Analyses indicate that competition resulted in cost savings for both programs .

## INTRODUCTION

Defense acquisition has a long history of competition. The Armed Services Procurement Act of 1947 required that contracts for property or services be formally advertised. OMB Circular A-109 directs that competition be used throughout a program, particularly during design and development. Competition at that point has the advantage of allowing the exploration of different alternatives. Competition often has been used in full- scale development. More recently, however, the government has emphasized competition in production, the explicit goal being lower prices and, possibly, better performance.

In the 1980s, Congress has prescribed production competition. In the Defense Appropriations Act of 1984, Congress required that any major acquisition program have either a certification that the system would be procured in insufficient quantities to warrant multiple sourcing or a plan for the development of two or more sources. In addition, the Defense Department has encouraged competition. The Defense Acquisition Improvement Program (the Carlucci Initiatives), instituted in 1981, includes an initiative to increase competition in the acquisition process. In 1984, the Defense Systems Management College (DSMC) published a handbook for program managers on enhancing competition [1].

Competition has a number of applications in defense procurement. We can think of the types of items that the government buys as being along a continuum with respect to quantity and complexity. Small, uncomplicated items that the government buys a lot of over the years are easy to compete. In many cases, these items are standardized, and it is relatively easy to obtain multiple sources. At the other end of the continuum, major weapons systems and subsystems are developed on a customized basis and produced in relatively small numbers. A company that wants to produce Sidewinder missiles cannot merely do some quick tooling and start producing them--a detailed technical data package is needed.

In this paper, we focus on competition as dual sourcing in the production of a major weapon subsystem, aircraft turbine engines. The two programs of interest are the Air Force's F100/F110 and the Navy's F404 programs. Dual sourcing in production typically requires that the government have a hand in developing an alternative source, just as it developed the first source. Other methods of enhancing competition in the production of aircraft engines, including vendor competition, are not discussed here.

In estimating the effect of competition on both the Air Force's F100/F110 and the Navy's F404 programs, the primary analytical tool used is the price-improvement or learning curve. The measure of effectiveness used is the decrease in engine procurement prices that can be reasonably attributed to the introduction of competition. The emphasis in the analysis of the F100/F110 fighter engine competition is the effect on Pratt & Whitney F100 unit prices of the introduction of the General Electric F110 as an alternative engine for powering F-15 and F-16 aircraft. In the case of the F404 competition, where functionally identical engines were bought from both General Electric and Pratt & Whitney to power the F/A-18 fighter, a more complete cost-benefit analysis is performed.

## F100/F110 ALTERNATIVE FIGHTER ENGINE

The progression of Air Force decisions that led to the fighter engine competition did not consciously start with the idea of second-sourcing F-15 and F-16 propulsion business. Initially, the Air Force wanted a stand-by alternative to the F100, its only engine to power its front-line fighters. An alternative fighter engine would provide insurance against the failure of Pratt & Whitney's efforts to solve the F100's numerous reliability, maintainability and operability problems, as well as against other eventualities that could threaten the viability of the F100. Implicitly, the Air Force wanted to gain leverage on Pratt & Whitney, whose response to F100 problems was judged unsatisfactory by many [2].

General Electric's F101 engine, which was developed for the B-1 bomber, formed the basis for the alternative engine. A modification of that engine, the F110, was developed for application to F-15 and F-16 aircraft. The primary objective of starting the competition was *not* the lowering of unit production prices. Instead, the emphasis was on obtaining more reliable, maintainable, and operable engines. The F110 also had the advantage of higher thrust [2].

We limited our analysis to the effect of the fighter engine competition on F100 prices. As the F110 and F100 engines are functionally different, and there is no pre-competition experience for the F110, no comparisons are made between F100 and F110 prices. Complicating analysis further were constant changes in the F100's configuration. Hundreds of millions of dollars of Component Improvement Program (CIP) funds were spent on developing fixes to address service-revealed problems. Engineering changes were in turn incorporated into F100 production engines. The introduction of competition coincided with a major model change from the F100-P-100/200 to the F100-P-220. Because of configuration changes, the F100's learning curve contains discontinuities.

In constructing a learning curve for the F100 production, lot unit prices for Air Force-procured installation engines are regressed against the cumulative quantity of all F100 engines, including those produced for foreign military sales (FMS). These data were obtained directly from Pratt & Whitney. In years where both F100-P-100 (original F-15 application) and F100-P-200 (F-16 application) engines were bought, prices for the F100-P-100 are used. We normalized prices to constant 1987 levels using propulsion industry indices developed the by the Naval Air Systems Command (NAVAIR). A nonlinear regression routine is used to simultaneously estimate lot midpoints and learning curve parameters. Indicator variables (1, 0) are used to account for shifts in the learning curve due to competition and engine configuration changes. The resulting curves are as follows:

F100 Unit Cost, 87K\$ = 7950 $Q^{-.15}$, learning curve slope = 90%

FY 80-81 Model Change = + 441,
significantly different from 0 at the .05 level

-100 to -220 Model Change and Start of Competition = + 177,
not significantly different from 0 at the .05 level,

$R^2 = .94$

Figure 1 presents the price-improvement curve for the F100 program.

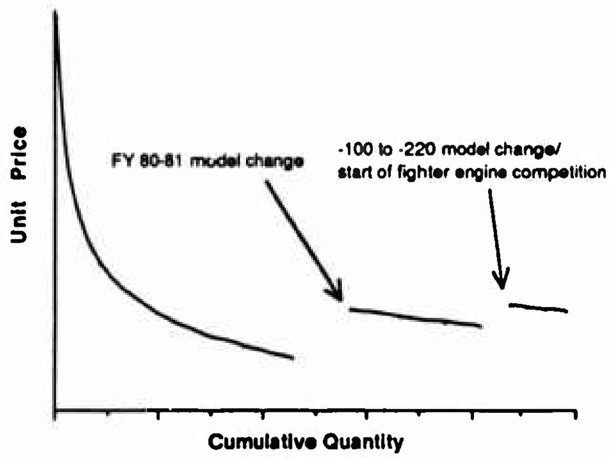


Figure 1. F100 Learning Curve Analysis

A large increase in unit price occurred with the fiscal year 1981 engine buy. The shift upwards in the unit learning curve at this point is estimated to be \$441,000 (significantly different from zero at the .05 level). The reason for this large upward shift in the learning curve is not entirely clear. One hypothesis is that fiscal year 1981 marked a large change in engine configuration. This hypothesis is supported by a relatively large decrease in the unscheduled engine removal (UER) rate for the fiscal year 1981 engines, where UER performance is considered an important indicator of engine reliability and durability.

As previously mentioned, the first year of competition, fiscal year 1985, corresponded with a major change in F100 hardware. This change was great enough to warrant a change in engine series designation from -100/200 to -220. The fiscal year 1985 buy causes a slight upward shift in the learning curve, estimated at \$177,000. This shift is not significantly different from zero at the .05 level. As the effects of competition are confounded by the model change, the results are open to interpretation. A reasonable interpretation is that the model change, which would have proven costly under the old regime (as evidenced by the large upward shift of the learning curve for the fiscal year 1981 buy) did not cause a statistically significant upward shift in the learning curve. In discussions with Air Force representatives at the propulsion system program office at Wright Patterson Air Force Base, the -100/200 to -220 model change was said to represent a substantial change relative to earlier F100 configuration changes. Given this interpretation, the introduction of competition into the F100 program has had a favorable effect on F100 unit prices.

It must be kept in mind that a reduction in production prices was not the primary goal of the fighter engine competition. The central motivation was the improvement of engine reliability, durability, and operability. Measuring the effects of competition on these aspects of engine performance is not attempted. Such an analysis would require a large data collection effort. In addition, field experience with the engines procured under competition is limited.

## F404 ENGINE

In the second-sourcing of the Navy's F404 engine, the objective of the competition was more clearly to lower procurement prices. The F404 engine did not suffer from a high level of service problems in the field, as did the F100. In establishing Pratt & Whitney as an alternative source of F404 engines, a series of "education buys" was non-competitively awarded. This differs from the case of the F110, where all production engines were bought on a competitive basis. The first buy of Pratt & Whitney engines was in fiscal year 1985, while the first buy actually competed was in fiscal year 1988. The effects of competition are examined from the initial establishment of the second source as opposed to the actual initiation of competition. The hypothesis is that the simple establishment of a second source should create downward pressure on lot prices.

Again the production price-improvement curve is our main tool of analysis. Data for both General Electric and Pratt & Whitney contract prices were obtained from the Navy. Additional F404 data supplied directly from Pratt & Whitney proved consistent with the Navy data. As in our F100 analysis, lot prices are normalized into constant 1987 dollars and quantities encompass all production, including FMS. Separate learning curves are estimated for General Electric and Pratt & Whitney experience. In order to test for the effect of second-source establishment on General Electric prices, a 0, 1 indicator variable is used to estimate a rotation parameter for the General Electric learning curve. The resulting curves are as follows:

G.E. Unit Price, 87K$ = 3886 $Q^{-.105}$, slope = 93%,

After Second Source = 3886 $Q^{-.135}$, slope = 91%,

$R^2 = .98$

P&W Unit Price 87K$ = 4026 $Q^{-.19}$, slope = 89%,

$R^2 = .95$,

The difference between the pre- and post-second-source learning curves is estimated by the rotation parameter, which is statistically different from zero at a .05 level of significance. The slope of the first-source learning curve declined after competition from 93 percent to 91 percent. The slope of the second source learning curve was even lower at 89 percent. Figure 2 presents the learning curves estimated for both Pratt & Whitney and General Electric experience.

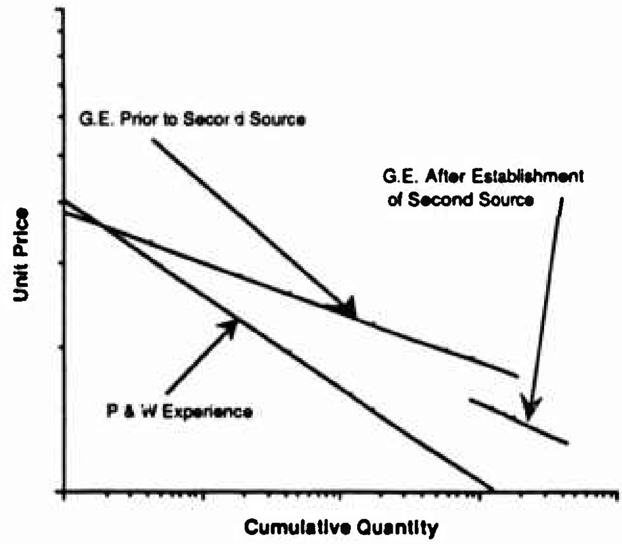


Figure 2. F404 Learning Curve Analysis

A possible confounding influence was revealed in discussions with NAVAIR representatives. Between fiscal years 1983 and 1984 the unit prices the Navy paid for their turbine engines decreased. The decreases were said to be a result of lower prices for advanced materials. The decreases in materials prices, however, are not reflected in the price indices we use, or in the behavior of F100 prices over the same time period. We attempted to test the materials price hypothesis by including an additional 1, 0 indicator variable designating all procurement lots prior to fiscal year 1984. The indicator variable is multiplied by an additive shift parameter whose value is expected to be positive. As there is only a single lot associated with the materials price decrease and not with second sourcing, it is difficult to distangle the two effects. Indeed, when both parameters are estimated, neither is significantly different from zero at the .05 level. They are however significantly different from zero at the less stringent .10 level. The resulting equation is as follows.

G.E. Unit Price 87K$ = 3615 $Q^{-.107}$, slope = 93%,

After Second Source = 3615 $Q^{-.125}$, slope = 92%,

Add $211,000 for lots procured before fiscal year 1984,

$R^2 = .98$

As expected, the rotation parameter is smaller when an attempt is made to account for changes in materials prices. When we look at the costs and benefits of the F404 second-sourcing, estimates of price savings generated by the equations with and without the materials-price shift parameter will be included in order to test the sensitivity of the results.

Benefits are quantified by comparing price estimates generated by the pre-second-source learning curve and G.E./P&W actuals for lots already definitized and estimates generated by the Pratt &Whitney and post-second-source General Electric learning curves for future lots. For these future lots, we assume even splits between G.E. and P&W with 200-engine lots through fiscal year 1992. Non-recurring costs were supplied by the Navy and include both second-source qualification costs as well as tooling costs. These costs are also normalized to constant 1987 dollars. A discount rate of 10% is used in calculating costs and benefits. Figure 3 shows estimated cumulative costs and benefits (savings) for the F404 competition where savings are estimated both with and without accounting for decreases in materials costs (baseline model and modified model). Given the two models and the above assumptions, net savings, or benefits, of the F404 competition range from approximately $125 million to $300 million in constant 1987 dollars.

## CONCLUSIONS

In judging the success of the two engine competitions, the use of decreases in unit prices as a positive criterion is most appropriate for the case of the F404. Given experience thus far, it appears the F404 competition has been a success. By concentrating on unit price effects we tend to ignore the greatest potential benefits of the F100/F110 competition--the decline in overall ownership costs and increased F-15 and F-16 operational effectiveness. Unfortunately, these are beyond the scope of the study. However, it appears that competition and a major model change occurred at the same time on the F100 without substantial cost to the government.

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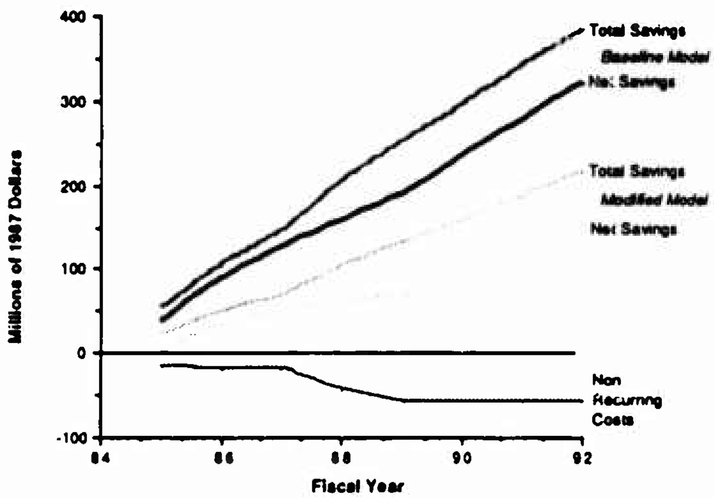


Figure 3. F404 Competition Cost-Benefit Analysis

SEPARATING MYTHS FROM FACTS IN COMPETITIVE WEAPONS SYSTEMS ACQUISITION

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ABSTRACT

Following the latest round of "procurement scandals," the Executive, the Congress, and the general public have been attempting to open defense acquisition to more competition. One result of this push was the Competition in Contracting Act. This paper attempts to separate myths from facts in the competing of weapons systems production. It is unfortunate that many policy analyses, as well as many major acquisition decisions, have been based upon the myth that introducing competition into weapons systems acquisition will always produce significant savings to the government. The fact is that dual source competition in major systems has resulted in additional costs to the government almost as often as it has produced savings. The paper provides theoretical explanations and empirical evidence concerning this major policy question.

INTRODUCTION

After publicity concerning $640 toilet covers, $436 hammers and other procurement problems, the Administration, Congress, and the general public began pushing to open defense acquisition to more competition. As a result, Congress enacted The Competition in Contracting Act of 1984 [1]. Due to this strong legislative and political pressure, "Think Competition" has become a slogan in defense acquisition circles, and dual source procurement has been suggested as one means of obtaining additional competition.

The purpose of this paper is to separate myths from facts in weapon system competition. It is unfortunate that many policy analyses, and many major acquisition decisions, were based on the myth that competing weapon systems would produce significant savings to the government.

The paper is organized as follows: the first section describes the pressure faced by the Department of Defense (DoD) to increase the use of competition in procurement. The second section discusses the unique DoD market environment, while the third section reviews prior studies which demonstrate the paradox that competition has resulted in <u>added</u> net costs to the government as often as it has produced the desired net saving. The next two sections present some theoretical and empirical data that explain the paradoxical findings. The final section summarizes myths and facts in weapon system competition and concludes with directions for future study for acquisition policy and decision.

COMPETITION IN DEFENSE ACQUISITION

There is a deep-seated and historic belief that the best model for government procurement is solicitation of price offers from a maximum number of qualified sources. Indeed, there <u>are</u> many advantages to the government of competitive procurement if it is applied properly. Various imperatives for competition in defense procurement will be discussed in this section.

Since 1809, Federal statutes, regulations, and executive orders have consistently required that government procurement must, to the greatest possible extent, be made on a competitive basis. In 1965, the then Secretary of Defense Robert S. McNamara indicated to the Joint Economic Committee (Hearings on the Economic Impact of Federal Procurement) that the General Accounting Office (GAO) had evidence of dollar savings on the order of 25 percent or more when competition was introduced for reprocurement of an item which had a sole-source procurement history [2]. Since then, this 25 percent savings figure has been quoted repeatedly by defense policy makers and observers. In 1969, the Subcommittee on Priorities and Economy in Government of the Joint Economic Committee called for vastly expanded use of competition for procuring all forms of Defense Department material [3].

This position has been reaffirmed both by the current Administration and by Congress. The most recent legislation is Public Law 98-369, which includes the

Competition in Contracting Act of 1984. PL 98-369 stipulates the use of dual sourcing by DoD and civil agencies in procurement. The President's Blue Ribbon Commission on Defense Management (a.k.a. the Packard Commission) also strongly advocated the increased use of competition [4]. This drive toward competitive procurement is reflected in various internal DoD initiatives and programs.

## DEFENSE MARKETS

Defense markets run the gamut from totally free competition to a DoD-created market with one buyer and one or two suppliers; from markets which provide many choices of product and product attributes to one in which a product exists only because the DoD has paid the price to create it. While a great majority of the 13 million annual procurement actions are conducted in a purely competitive fashion, the majority of defense procurement dollars have been spent in a market where the government is the only buyer and the number of potential suppliers is small. In FY1985, noncompetitive contracts awarded by DoD totaled $96 billion [5].

Competition in traditional markets arises when buyers and sellers are numerous and individually so unimportant in the market that their separate actions have no meaningful impact on market price. A great majority of DoD procurement actions are in such a market. However, the majority of procurement dollars are for major weapon systems which poses a unique problem.

For major systems the government is the only buyer. It dictates the size of the market and the timing of demand. Additionally, these systems usually involve state-of-the-art technologies, and hence bear little relation to the infamous ubiquitous "widget" which is produced and sold in traditional competitive markets. Compounding these uncertainties to the supplier is the heavy investment needed to become a supplier. In this kind of environment, the availability of suppliers may be linked to the willingness of the government to absorb at least part of the risk, which could mean that the government must incur investment cost to develop a supplier in order to introduce a competitor. This is an element which is unique to the major defense systems market and is not well understood by those unfamiliar with the defense market. Lack of understanding of the uniqueness of defense market contributes to the allusion that competition in defense acquisition always produces lower prices to the government.

## GAINS AND LOSSES FROM PRIOR DUAL SOURCING

Since McNamara's statement about the 25 percent savings from introducing a competitor, numerous studies had been conducted to examine the financial consequences of dual source competition. Earlier studies, with questionable methodologies, reported dramatic savings from introducing a competitor. Such studies may be found in the references of Greer and Liao [6] and Beltramo and Jordan [7]. Despite their questionable methodologies, these studies were prominently cited as evidences of savings from introducing competition to weapon systems [8]. With the improvement in research methodologies, studies conducted in recent years revealed that competition has resulted in added net costs almost as often as it has produced the desired net savings. A comprehensive survey of prior studies can be found in the literature [6,9,10] and, therefore, will not be repeated here. We will pursue the contradictory findings and provide additional insight on the inconsistency.

Although many dual-sourced weapon systems programs have been studied, we will examine only those with verifiable data. Our interests are not on predicting the size of dollar savings but on pursuing the paradoxical finding that dual source competition has resulted in added costs as well as net savings. Hopefully, these efforts will provide some leads for the direction of future policy analysis.

Table 1 lists seven dual-sourced programs which have been examined closely in several studies [7,9,11]. The program savings (losses) data were taken from earlier studies, and the amount of savings (losses) was calculated by comparing actual prices paid by the government after the program was dual sourced to the amount that would have been paid had the government continued sole source procurement.

We examined the time period during which each program was in the dual source competition mode, as shown in Column (3). The aerospace industry's capacity utilization rate during the dual source phase of each program is shown in Column (4). Note that the three programs realizing savings from dual sourcing were in the dual source procurement phase when the aerospace industry's capacity utilization rates were relatively low. On the other hand, the other four programs, which resulted in losses, were in the dual source procurement phase when the industry's capacity utilization rates were relatively high. It should be apparent to the reader that the likelihood of realizing savings or suffering losses from dual sourcing a major weapon system is related to the business environment of the industry.

Figure 1 shows the same data in chronological order. From a historical perspective, the three dual-sourced programs which resulted in saving to the government (Bullpup, TOW, Rockeye) coincided roughly with either the post-Korean-war era or the post-Vietnam-war era. On the other hand, dual sourcing Sidewinder, MK-46, and Shillelagh resulted in additional cost to the government because they coincided with the height of the Vietnam war when the aerospace and the ordnance industries were at their busiest since WW II. It is clear that creating a second source as the "competitive" supplier does not always result in a competitive environment in an economic sense. Whether or not the government can realize the benefit of competition depends on the timing of dual sourcing. In the next two sections, we will provide additional insight to illuminate this point.

## CONTRACTORS' FORWARD-PRICING STRATEGIES

The analysis in the preceding section suggests that contractors adjust their bid prices according to the business environment of their industry. Given the multitude of laws and regulations governing the government contractors' cost accounting and pricing, one might wonder how it is indeed possible to have varying levels of prices. To understand why this is possible, it is necessary to understand the forward-pricing system used in defense and other large civilian contracts.

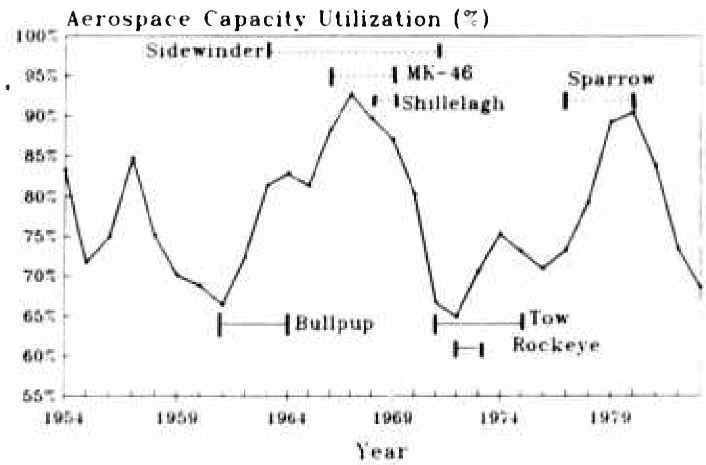
Under the forward-pricing system, a bid price must be submitted well in advance on the often highly uncertain estimated cost to perform the contracted work. The uncertainty factor is particularly serious for defense contracts, since most involve state-of-the-art tech-

Table 1
Relationship Between Savings and Economic Environment

| (1) Procurement Program | (2) Savings or (Loss) Due to Competition | (3) Time Period in Dual Source Phase | (4) Average Capacity Utilization During Dual Source Phase |
|---|---|---|---|
| TOW Missile | 26.0% | 1971-75 | 63.5% |
| Rockeye Bomb | 25.5 | 1972-73 | 70.9 |
| Bullpup AGM-12B | 18.7 | 1961-64 | 76.2 |
| Shillelagh Missile | (4.7) | 1968-69 | 87.0 |
| Sparrow AIM-7F | (25.0) | 1977-80 | 81.6 |
| MK-46 Torpedo | (30.9) | 1966-69 | 91.6 |
| Sidewinder AIM-9D/G | (71.3) | 1963-71 | 82.3 |

*From Beltramo and Jordan [7].

Figure 1
Capacity Utilization & Dual Sourcing



nologies. When the industry has ample idle capacity, such as in a post-war era, a firm may be so eager to compete for a contract that it will base its bid on an estimated cost figure which it may only have a small chance of achieving. Figure 2 depicts this decision scenario [12]. This hypothetical example assumes that the estimated cost to complete a contract ranges from the highly optimistic $50,000 (only 0.5% chance of achieving this cost figure) to the worst case scenario of $150,000. The top frame shows the estimated probability of occurrence of each cost figure. The bottom frame shows the cumulative probability of, or the chance to equal or better, a particular cost level.

Point A in the bottom frame of Figure 2 shows the estimated cost if the contractor is willing to accept a 50:50 chance. The corresponding cost estimate for the contract is approximately $98,000. The contractor may add another 10% as his profit target and submit a bid of $107,800 in the hope of winning the contract.

On the other hand, the contractors do not face any pressure to submit a competitive bids if business conditions in the industry improve and each firm has ample business opportunities. There are several reasons for this. For one, during an economic boom, a profit making firm is less likely to engage in price competition. This reduced willingness to compete in price would be further compounded if a contractor senses that other potential contractors also share this reduced willingness to compete. A booming economy also implies alternatives for the firm's production capacity. Sufficient profit opportunity must exist in order to justify capacity expansion, and, before the capacity can be expanded and made operational, existing projects must compete with each other for the limited capacity. Under all these circumstances, a contractor will not submit a bid unless he/she is highly confident that the estimated cost level can be equaled or bettered.

If the contractor desires a higher confidence level, say 75%, the estimated cost would be approximately $110,000, as shown in Point B in Figure 2. Adding a 10% profit target would bring the bid price to $121,000, a much higher bid compared to the $107,300 when the economy is not as good. Therefore, there is a close association between a contractor's bid price and the condition of the economy. This deduction is consistent with the empirical observation made in the preceding section that the potential for the government to realize the benefit of weapon system competition depends on the timing of dual sourcing.

## STRUCTURAL DEFICIENCY OF DUAL SOURCE COMPETITION

Apart from the timing issue discussed above, there is a structural deficiency in the way a major weapon system can be procured competitively. Dual source competition allows the contractor and the government opportunities to exploit the market situation to the advantage of each party. The government's objective, as reflected in PL 98-369 and other policy directives cited earlier, is that competition will put competitive pressure on the supplier and result in a fair price to both parties. However, dual source competition also creates opportunities for the contractor to exploit. First, in return for the competitive market pressure with competitive bidding, the government gives up much of the regulatory authority it enjoys over verification of the contractor's cost and pricing data. Thus, it becomes easier for the contractor to obtain higher profits under a dual source competitive contract than under a sole source negotiated contract if the market environment allows it. Second, in order to maintain two sources of supply, it is necessary for the government to award a minimum sustaining quantity to the higher-priced competitor. Both of these factors put the government in a disadvantaged position in dealing with the contractors. In this section, we will discuss various pricing strategies that can be used by the contractor to exploit the dual source competition situation [13].

### The Minimum Sustaining Rate

In a dual source competition environment, the lower-priced bidder is typically awarded the major portion of the annual quantity, but the higher bidder is also awarded a quantity that represents the minimum level of production the contractor requires to stay in production and remain viable. This guarantee, resulting from the government's desire to maintain two viable production sources, actually diminishes competitive pressures and puts the government in a disadvantaged position. Hence, there is no competitive incentive for the suppliers at the minimum sustaining quantity level, and the government can expect an inflated bid price from both of the suppliers at this level.

### The Production Rate Effect

Due to the splitting of the production quantity between the two contractors, the government must forego some of the savings associated with cumulative production experience. The smaller production rate also means higher unit cost because neither contractor is able to fully realize the economies of scale in production. Therefore, the split award should result in higher production costs to either of the two contractors than if the entire year's production were awarded to the low bidder. The argument for using dual source competition, of course, rests on the assumption that the loss of economies of scale and cumulative production experience should be more than offset by the smaller amount of profit the contractor would be forced to accept under competition. Therefore, it is usually suggested that the bid prices should be lower under a competitive environment, compared to a sole source acquisition, thus resulting in net savings to the government.

### Unequal Competitive Position Between Contractors

If the second supplier is established after the first supplier has had some production experience with the weapon system in question, the competitive position of the two contractors most likely will be unequal. Under this circumstance, the anticipated competitive pressure from dual sourcing may diminish, or even evaporate completely.

First of all, being the developer of the system and having had some production experience, the first supplier often enjoys a cost advantage over the new supplier. Other things being equal, the more experienced producer will have a lower production cost and can underbid the new supplier. This problem is compounded if the first supplier continues to win the majority of annual quantities in a dual award environment.

Second, there is a dilemma facing the government in establishing the second supply source. Being the only buyer in the major weapon system market, the government often has to provide financial resources to induce other contractors to establish the production facility for a

Figure 2
Cost Uncertainty & Bid Prices

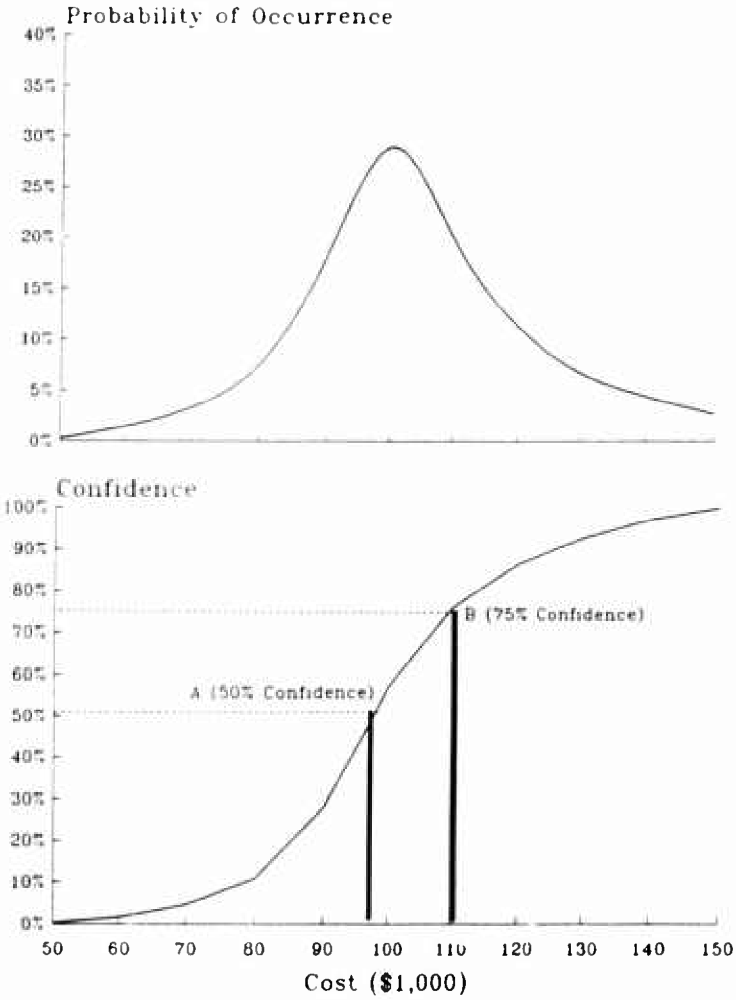
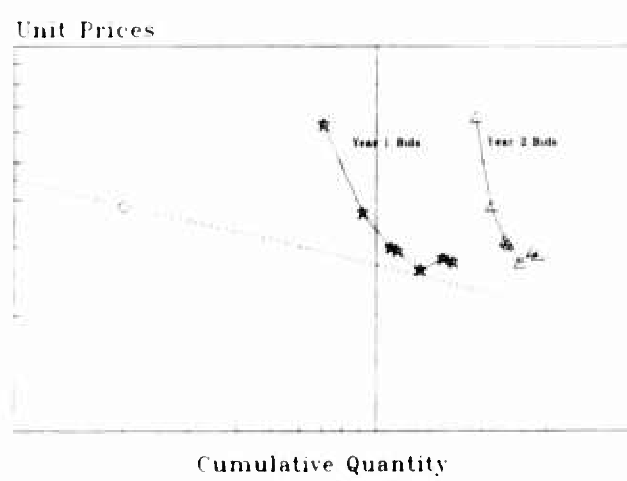



Figure 3
Price Gaming Under Dual Sourcing



particular weapon system. Expanding the capacity beyond the level needed clearly is not economical. But the combined production capacity of the two firms may far exceed the actual requirements if the second source is established at the same production capacity level as the original source. On the other hand, if the second source's production capacity is established at a level lower than the total government requirement the second source would not be in a position to bid at the higher percentages of the annual requirement, thus creating a virtual monopoly for the original source at higher quantities.

Evidence of Contractor Price Gaming

The various scenarios discussed in this section reflect the structural deficiency of dual source competition, which presents many opportunities for contractors to submit inflated bid prices. This hypothesis is consistent with the forward-pricing strategy discussed earlier in providing the explanation for the paradoxical results of prior dual sourcing experience. To support our logical hypothesis, we will present an actual case which reflects the price gaming hypothesis discussed above.

Figure 3 shows the bid prices submitted by a contractor of a major weapon systems under the dual source competition environment. We have masked the identity of the program and contractor and the numerical values of the data in order to protect the proprietary information, but the relative scale of all prices is accurate.

The circle on the left in Figure 3 is the actual unit price awarded when the contractor was the sole source supplier. The dashed line going through this circle and extending downward to the right is the projected sole source price using the contractor's historical price-reduction curve.

In dual source competition, the government annually solicits bids from both suppliers for various quantity levels. The lower price bidder is awarded the larger share of the government's annual quantity requirements while the higher price bidder gets the smaller share, usually the minimum sustaining rate to keep the loser's plant active. The stars on the solid line represent the bid prices for the respective quantity levels (from 20% to 80% of total annual quantity at 10% increments, also known as the step-ladder bids) submitted by the contractor in the first year of dual source procurement. The triangles represent the second year bids.

For comparison, the dotted lines beneath the bid price curves represent the reasonable step-ladder bids. On a log-log graph such as Figure 3, these bids should form a downward sloping straight line to reflect the production rate economies for larger quantities. The dotted line should also intercept the dashed long-term price reduction curve to reflect the effect of learning from cumulative production experience. Comparing the step-ladder bids to the respective reference line, one can observe several irregularities in those annual bids.

First, at the minimum sustaining rate (20%) level, the bids for both Year 1 and Year 2 are far above the reasonable bid line, indicating that the bid prices are too high at this quantity level. This reflects the point made earlier that, at the minimum sustaining rate level, there is no competitive pressure whatsoever and, no matter who wins the larger share, the other contractor will be a "happy loser."

Second, the bid prices went up for the 70% and 80% quantity levels. As the reasonable bid price curves show, the higher the quantity produced, the lower the unit price should be. Increasing the bids at high quantity levels is not economically justifiable and reflects the point made earlier that, if one contractor senses no competitive pressure from the other side at that quantity level, it can and will take advantage of the situation.

Another irregularity is that Year 2 bid prices were higher than those in Year 1. Since the data have been adjusted for inflation, it is reasonable to expect decreasing prices for subsequent years because of the learning curve phenomenon typical in the aerospace industry. These increasing prices are another example of price gaming which is made possible under dual source "competition."

## SUMMARY AND CONCLUSIONS

Due to the unique market structure, procurement of major defense systems has been done primarily on a sole source basis. Current policy calls for expanded competition in procuring all forms of defense systems and material. Dual competition has been suggested as one means of obtaining competition in the major system procurement. However, extensive study of prior dual source competition experiences indicates that the results from this form of competition have been mixed.

In this paper, we have provided some conceptual and empirical explanations for these paradoxical findings. Our attempt is to separate the myths from the facts of major weapon system competition:

**Myth**: Dual source procurement is a competitive procurement.

**Fact**: In economic theory, competition implies that there is a large number of suppliers and an individual supplier's action has no significant impact on the market. Dual source procurement is a classic case of duopoly which is, in fact, much closer to monopoly than to competition.

**Myth**: Dual source "competition" will force the suppliers to reduce their prices.

**Fact**: The primary condition under which the two suppliers in a defense industry duopoly would engage in price competition is when both are hungry for business, i.e., when the industry is in a slump. Even in this case, both suppliers can inflate the bid price at the minimum quantity without any penalty. Thus, at the minimum sustaining rate under the dual source procurement structure will always produce a "happy loser."

**Myth**: Dual sourcing a previously sole-sourced weapon system can produce savings on the order of 25% or more.

**Fact**: This myth was the direct result of McNamara's comment and has been quoted repeatedly by Washington decision makers in the past two decades. It is possible that this figure may be valid for a particular program, but there are many counterexamples. The size of savings and losses from dual sourcing varies. The fact is that the government must pay for introducing a second supply source in the form of initial investment, loss of economies of scale, and inflated prices for the minimum sustaining rate. Therefore, whether or not the government can realize savings from dual sourcing a major weapon system depends on the economic condition of the aerospace and ordnance industries. If the suppliers do engage in price competition, savings from the lower prices must be larger than the price the government paid for introducing the second source.

Understanding the myths and facts of major weapon system procurement is crucial in setting acquisition policies. Under a competitive bidding environment, as currently assumed by dual source procurement policy, the contractor can charge what the market will bear. On the other hand, under a monopoly environment, the contractor must substantiate all cost figures. Since dual source procurement is in reality closer to monopoly than to competition, regulations must be modified to eliminate those structural deficiencies of the current system.

In addition to separating myths from facts, our analyses of dual source competition policy also provide additional insights into contractors' pricing decision processes. We believe that these additional insights can shed some light on the direction of future policy studies. Clearly, the numerous attempts by the government to develop a method to quantify potential <u>savings</u> (as opposed to potential savings as well as losses) from dual source competition were misdirected. Our analysis shows that it is possible to determine the optimal timing to introduce a second source (or not to introduce it at all), but it would be futile to assume only savings result and then attempt to estimate the size of potential savings.

We believe that future policy research should focus on other viable alternatives to enhance competition at the major system level. These include major component breakout and multiyear contracting, among others.

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# SOURCE SELECTION IN THE INTERNATIONAL ENVIRONMENT

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## ABSTRACT

Cooperation with our allies in research and development is becoming more commonplace. Spawned largely by funding provided by the Nunn Amendment (1) and the regulatory relief provided by the Quayle Amendment (2), the various military departments have witnessed a variety of cooperative programs in the past few years. However, in order to truly perform in a cooperative environment, the US must share responsibility for important program decisions. One of the most basic of program decisions is the selection of a contractor or contractors to perform work for the participating nations.

Little guidance exists on how to perform a competitive source selection in an international environment. This paper provides insights into specific situations and problems you will encounter in performing such a source selection. It is based on the author's experience as attorney for the Autonomous Precision Guided Munition (APGM) program. APGM is an eight nation NATO program for which the United States serves as lead nation. APGM source selection efforts resulted in two contracts being awarded in June 1989 following a competition between four international censortia.


## INTRODUCTION

In prior years, the traditional United States approach to "cooperative programs" had been to keep decision making authority in our hands and at best to allow a few non-American "observers" to offer their national opinions. This was accepted since the few cooperative programs tended to be bi-laterial and usually involved incorporation into an existing later stage United States Program. In these programs the US usually was contributing the majority of funds and kept the rein on such decisions as source selection. There were some exceptions such as the Terminal Guidance Warhead part of MLRS where allies were given some real authority, but these programs were rare.

With the advent of the Nunn and Quayle Amendments, cooperative research and development was given a great impetus. The US opened the door to a wide area of cooperation with our allies. No longer were we merely incorporating an ally into an existing program. Now we found ourselves one of many, forming together for earlier stage programs. Likewise, no longer was the United States necessarily contributing more than any other nation. In those international programs involving the award of industrial contracts, this has meant learning to adapt our source selection process to accommodate this new "internationalism."

For the Army the basic guide for Source Selection is the Army Material Command's three volume "The Source Selection Process"(3). This pamphlet is meant as guidance and its procedures are not mandatory. You therefore have discretion and are encouraged by the AMC Phamphlet to adapt the process. This is essential for an international program.

It appears to be part of our national personality to want to play a leadership role in programs. Of the "Nunn" programs in the Army involving the award of contracts, the US has always "volunteered" to be lead nation and accept the contracting duties that came along with that responsibility. Our system, however, does not naturally lend itself to an international program and you will be faced with numerous hurdles in adapting US source selection procedures to accommodate an international program.

## TEXT OF PAPER

Our allies have varying expertise concerning the manner in which the US awards contracts to industry. In a system which we ourselves have a hard time understanding, you can imagine the problems some of our allies have. By and large, our allies do not do competitive source selection. They will normally just award a contract to an industrial firm they have decided is best suited to perform such work. Such contracts will be rotated among those firms the government wishes to keep in their industrial base. Overall, it appears that the Canadians, British, Germans and Israelies understand our procurement system best because they have dealt with it the most. However, do not take any knowledge for granted when working on an international program. The contracting officer will often have to serve as a teacher.

Under the Quayle Amendment, US participation is conditioned upon each nation contributing its equitable share to a program. Likewise, each participant will want its "equitable" say in matters of program management such as source selection. This is especially true in many programs since the US contribution is no greater than other nations. A program's Memorandum of Understanding (MOU) will have to define what role each nation will play in that program's source selection. A basic question will be whether each participating nation should have an equal vote or whether a nation's vote should be tied to its cost contribution. I would argue that rather than risk protracted arguments with smaller allies, agree to the one nation one vote principle. International programs can only work with unanimous agreement so it really does not pay to have proportional voting in source selection. If a nation is unhappy with the source selection decision they will terminate participation or fail to sign the document authorizing that phase of the program.

The next decision usually concerns who the Source Selection Authority (SSA) will be. This issue has been handled in two ways. Initially it was felt that the SSA had to consist of one individual. A multinational group would be established below the SSA and they would make a "recommendation" to the SSA for award and the SSA would implement it. However, this can cause bad feeling with our allies who feel the actual decision is being removed from them. There is no need for this potentially troublesome course of action since a single SSA is not mandated by our regulations. For the purpose of international programs there is no reason why the SSA can not be a group consisting of a senior individual from each participant. This allows each nation the assurance that they are truly a part of this key program decision.

Depending on the nature of your program, you may or may not want to have a Source Selection Advisory Council (SSAC). I have found it provides a good place for the input of the National Program Managers. You will have the experts in each technical field serving on the Source Selection Evaluation Board (SSEB) and you will have the upper level, traditionally Major General, serving on the SSA, so an SSAC provides a good middle level for the National Program Managers to digest the SSEB findings and brief it to their SSA.

The toughest part of your multi-national source selection is undoubtably the SSEB. Prior to the SSEB ever convening you will have to have a Source Selection Plan (SSP) in place. Although all nations want to develop this system you will find that they do not all want it for the same reasons. Therefore, the manner in which they propose to evaluate offers will differ. For instance, the US traditionally favors a weighting strategy putting an emphasis on individual components whereas many of our allies want the predominant criteria to be overall performance. You will further find that since nations have different operational needs for an item, an important element to one nation may have no importance to another nation. For example, Europeans just will not share the same concern as the US for how a system performs under desert conditions. The SSP will wind up as a compromise document so just make sure you get in it what you really need.

In staffing your SSEB you will have to be careful to distribute responsibility among your various participants. You must not bruise any national egos. Indeed you will find there is much technical, management and cost expertise outside the US. It may be beneficial to have your committees equal in number to your participants so that every nation may have a committee chairman. (for an example of this, see Chart A)

In dealing with SSEB personnel you will have an interesting situation as many of our allies' technical experts actually work for industry but will be representing their Government on the SSEB. Remember, our allies do not make the sharp differentation between Government and industry that we make. Their industry work very closely with their ministries of defense and the ministries rely on industry for their technical expertise. They do not have government experts as we do. So you will have to rely on your foreign counterparts to screen their people and make sure there is no conflict with this particular procurement. In the US we have our SSEB members sign non-disclosure statements and statements of financial interest. This is a problem for some of our allies as their unions object to this practice. The unions claim they must meet these criteria as a precondition to being hired and to make them sign a statement to that effect now gives the appearance of a lack of trust. Rather than press this issue it will be more beneficial to establish specific rules for how SSEB personnel must act and handle information. Then put the responsibility for enforcement of these rules on each National Program Manager.

Traditionally, an SSEB will all be "locked" in one room together for many weeks until their evaluation is complete. Some international programs have sought to do this. Our allies are willing to work together on the evaluation but they have become adamant that they must first have the proposals in-country for review. It is a tremendous burden to ask each nation to send all necessary technical experts overseas for many weeks. What has come about is the agreement to allow each nation to study the proposal in-country for approximately four weeks (National SSEB's) and then send the appropriate personnel to the international SSEB. Needless to say, this procedure often results in nations coming over with an established "national position" but it is unavoidable. Just make sure you have each National Program Manager ensure that security and non-disclosure standards are met while the in-country review is conducted.

Logistically, your international SSEB can be a nightmare. You will have nations sending anywhere from a few to over twenty individuals each. It will take careful coordination to obtain the appropriate facilities, equipment, telephones and other supplies for this group. Depending on the nature of your program, you may need to have interpretation available for each individual work group. SSEB personnel sent by our allies will have less command of English than the more senior level people you have previously dealt with. Depending on the nations involved in your program, many SSEB experts may be unable to function in English. This will slow the work of the SSEB and make your logistical planning far more difficult.

In preparing your SSEB findings and report, it will be a consensus building procedure. Hopefully, many minority-type positions will be resolved during SSEB discussions. Those minority positions which remain will have to be set forth and explained in the SSEB report. Just when you have a report and feel pretty good, you will remember that you will have to re-do the SSEB procedure for Best and Final Offers.

In reaching their source selection decision, the SSA will be split between two major objectives. Some nations total interest will be in the technical objectives of the program. Other nations, while interested in the technical objectives, will be even more concerned over the amount and quality of contract work being performed by their nation. Therefore, reaching that unanimous SSA decision may be difficult but to date it has been achievable.

Upon the SSA reaching its decision, it will still take some time to be able to actually award the contract or contracts due to varying national staffing and funding requirements. You should therefore plan a press release from each Ministry of Defense stating what the decision was and when contract award is contemplated. It pays to issue an accurately worded statement rather than have all kinds of inaccurate stories leak out. For the United States, this statement should be coordinated within the appropriate service prior to its release.

CONCLUSIONS/SUMMARY

As we enter an era of reduced resources, working with our allies becomes more important if not essential. Part of working with our allies will involve decision making as to award of contracts. Performing this source selection in the international arena is possible. To succeed you will need patience and above all else flexibility. Our system, designed to competitively select the best item for the money, can still be used and perhaps even benefit from the experience and knowledge of our allies.

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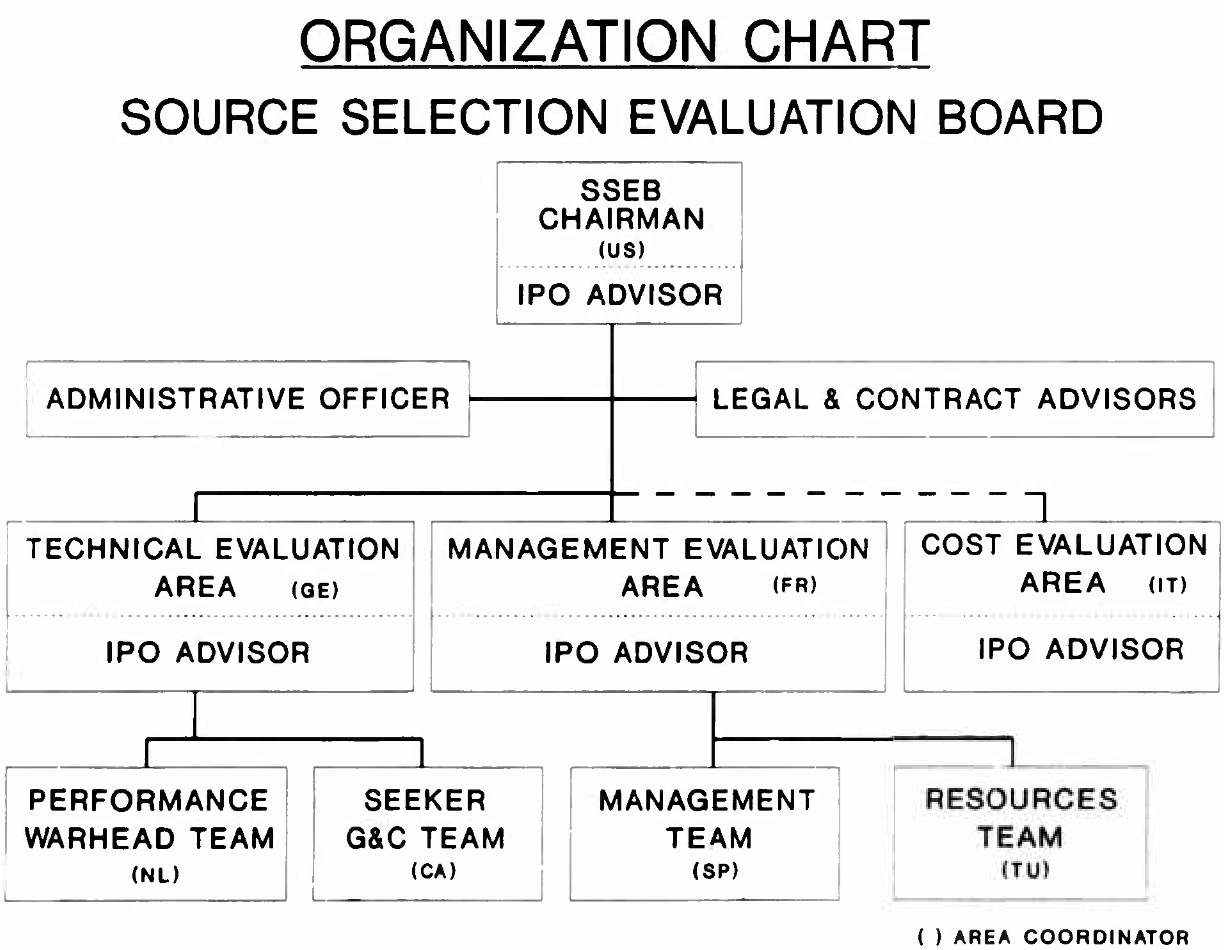
CHART A



# RESEARCH AND DEVELOPMENT

RESEARCH AND DEVELOPMENT

# COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS

Joseph T. Bolos
and
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## ABSTRACT

In 1980 Congress passed Public Law 96-480 known as the Stevenson-Wydler Act which was designed to encourage commercialization of research results under government contracts. The law allowed commercial organizations to retain intellectual property rights for purposes of commercializing the research product. In 1986 the law was amended to extend these principles to include inventions made in government laboratories by government personnel.

The intent of the law is to assure that the results of appropriate government technological inventions are pushed into the private sector for commercialization aimed at enhancing U.S. competitiveness in the world marketplace.

Government laboratories and commercial partners can now enter agreements without regard to all of the formalities required under federal acquisition regulations.

Cooperative Research and Development Agreements (CRDAs) are the legal instrument created by the Act which identify the arrangements between the Federal laboratory and commercial partner. Under these agreements the Federal laboratory inventor will receive a minimum of 15% of whatever royalty arrangements are negotiated up to $100,000 per year and more with presidential approval. The sponsoring laboratory may receive most of the remainder.

CRDAs can be very complex agreements. Some issues which must be addressed are consideration of intellectual property rights, use of facilities and equipment, funding arrangements, royalty amounts, rights to inventions made jointly, and licensing agreements.

Many government agencies have quickly implemented the Act and government inventors are receiving substantial royalties.

## INTRODUCTION

<u>Why should I read this paper? What's in it for me?</u>

If you are a Government scientist or engineer, imagine increasing your income by $100,000 per year. If you are a Commander or Laboratory Director, envision potentially bringing millions of dollars in nonappropriated funds into your activity which can be spent in a myriad of ways. If you are a commercial company and know of an invention in a Government lab that can be commercialized, imagine going to that lab and, on an exclusive basis, entering into an agreement allowing you to commercialize and market the invention in exchange for payment of royalties. These are not hypothetical concepts but current events taking place in Government laboratories.

In 1980 Congress had by PL 96-480 (known as the Stevenson-Wydler Act of 1980) and a later Presidential Executive Order, already encouraged commercialization of research supported under Government contracts. The law allowed commercial organizations to retain intellectual property rights in inventions made by the contractor's personnel under Government contracts even though the Government paid for the work. It also allowed them to patent and license these inventions. In 1986, PL 96-480 was amended to extend these principles to include inventions made in Government labs with commercial potential.

Now Federal laboratories are entering into Cooperative Research and Development Agreements (CRDAs) under the authority of the Technology Transfer Act of 1986 (PL 99-502 which amended PL 96-480). The intent of this law is to assure that the results of appropriate Government technological inventions not only become available to states and local entities but also to the private sector for commercialization. The aim is to enhance ultimately America's competitiveness in the world marketplace. It recognizes that technology and industrial innovation is important to social well being. The Act allows Cooperative Research and Development Agreements which are not covered by laws and regulations applicable to acquisition contracts and grants. It also establishes mechanisms for sharing information on technological advances and facilitates further development of the technology to make it useful in the private sector. This paper will concentrate on the use of those newly authorized Cooperative Research and Development Agreements (CRDAs).

What are CRDAs and who can use them?

CRDAs are a legal instrument created by the Technology Transfer Act which allow Federal laboratories to enter into agreements with other partners, including but not limited to industrial partners. The intent of such agreements is to commercialize the inventions of unclassified technologies of the Federal laboratories. The Federal laboratory inventor will receive a minimum of 15% of whatever royalty arrangements are negotiated, up to $100,000 per year and more with Presidential approval. The laboratory may receive most or all of the remainder. The laboratory can use its funds to pay for expenses incidental to the administration and licensing of inventions; reward scientific, engineering and technical employees; further technical exchange or education in mission R&D disciplines or support activities related to licensing potential.

The Act allows each Federal agency to delegate authority to enter CRDAs down to Directors of laboratories, and the Executive Order makes this delegation mandatory. It authorizes Federal laboratories to agree to grant intellectual property rights in advance to collaborators to inventions made in whole or in part by Federal employees under Cooperative Research and Development Agreements. It also reaffirms the exclusive licensing of any inventions already developed by the laboratory personnel.

The Act also provides that special attention should be paid to small businesses when entering into CRDAs and a collaborator should be a firm that does most of its manufacturing in the United States.

The Cooperative Research and Development Agreement is not a contract nor a grant as they are defined in Federal statutes. Therefore, it is not necessary to meet the conditions required by the Federal Acquisition Regulation (FAR) or the policies issued by the Office of Management and Budget for grants. Competition is not specifically required. There are no dollar thresholds, minimum number of offerors or cost analyses. There is no regulatory need to include any of the clauses required by the FAR. However, some clauses are required by other laws.

Since there must be provisions to control a variety of issues such as data rights, property ownership, and facilities usage, some of the agreements are very complex. While not defined as a contract for purposes of application of Federal statutes addressing contracts, the CRDA does, in fact, create a legally binding and enforceable agreement. This means that basic contract legal principles apply to these arrangements and should be considered in the development and enforcement of the CRDA. Other laws such as those covering covenants against contingent fees and gratuities, EEO, and Export Control apply to the arrangement notwithstanding the fact that the FAR is inapplicable.

The subject matters of CRDAs are as varied as the creative ideas in the minds of the inventors. For forestry, it can be growing a better tree and commercializing for the purpose of providing the public with inexpensive access to more durable wood. In automotive design, the CRDA could implement the transfer of the technology of a better battery that will retain captured solar energy and provide for an industrial partner to develop, test, and mass produce the finished product. In aircraft equipment, the CRDA could cover the collaborative development of better defrosting or deicing equipment.

Since the Cooperative Research and Development Agreement is neither a Federal contract nor a grant, it is questionable as to whether the Contract Disputes Act is applicable in the resolution of disputes. Usually, CRDAs provide for independent reviewing officials, however, judicial review may be obtained under the Administrative Procedures Act.

What is the "transfer of technology?"

Technology can be oral or written data or hardware. The Federal laboratory may provide and share personnel, facilities, equipment or other resources related to the transfer of technological developments. The Federal laboratory cannot provide funds, however, it can receive funds from one or more of its collaborating partners.

Is anyone really doing this?

Many Government agencies have quickly implemented the Technology Transfer Act. They have issued policy statements and directives to their technical personnel and management, and have created model CRDAs and Patent License Agreements. Their laboratories and inventors are already receiving income and royalties stemming from their Cooperative Research Agreements and Patent Licensing Agreements. Frequently, the CRDAs cover a sharing between Government and commercial laboratories and later another production partner can be added to market the development. National Institutes of Health, U.S. Army Corps of Engineers, and the Department of Commerce are progressive agencies in the development and implementation of CRDAs. The National Aeronautics and Space Administration has, since 1958, had authority under the Space Act to enter CRDA type agreements and has done so extensively.

How is the issue of Patents covered under CRDAs?

The Technology Transfer Act reaffirms the licensing of Government developed technology through a patent license. It also permits the transfer of rights for anticipated patentable inventions developed through the collaborative efforts covered in a CRDA. Thus, patents are basic elements of the Cooperative Research and Development Agreement.

However, typically, under CRDAs the U. S. Government shall obtain a non-exclusive, irrevocable, paid-up license to practice the invention or have the invention practiced throughout the world by or on behalf of the U. S. Government.

What are the advantages of technology transfer?

In his paper entitled Implementation of Cooperative Research and Developments, Richard A. Stern, (6) Senior Technical Staff, Office of Research and Technology Applications, U. S. Army Electronics Technology and Devices Laboratory, gives reasons and benefits for entering into CRDAs. The following are some excerpts:

"An organization's facilities and manpower can be leveraged through working with industry and academia under a CRDA (likewise for industry and academia). New interactions provide scientists and engineers (S&E's) with increased professional development and the introduction of new technology and new opportunities.

- The CRDA can be effectuated simply, without involving the procurement process.

- Team effort can solve technological problems which heretofore could not be solved on an individual basis

- Technology transfer is not really that new or different for most of us. We have always worked with others outside of our organization on an informal basis. This occurs as simply as discussing technological problems with others, exchanging thoughts and ideas, extending loan of equipment, or performing tests or a service for a fellow technologist as a favor. The Technology Transfer Act and CRDAs formalize, expand, renew and strengthen these relationships.

- CRDAs can sometimes be considered as an addition, expansion, or continuation of a project, and can thusly be used to provide that extra effort sometimes needed to successfully complete a program effort when lack of mission funding would otherwise bring a project to a close."

Additional reasons are given by Dr. Philip Chen, Jr., (1) Associate Director for Intramural Affairs, National Institutes of Health. The following are excerpts from his paper entitled, Organizational and Operational Implementation of the Federal Technology Transfer Act at NIH and ADAMHA.

"The assurance up-front to a participating company of an exclusive license to any patented inventions that might arise during the collaborative research is a considerable incentive, because existing Government-owned patents can only be licensed exclusively through a rather tortuous process...."

"The potential rewards to Government Laboratories and scientists are also increased as a result of the Federal Technology Transfer Act. Specifically, Government scientists can receive a more liberal share of royalty and license fee income as a result of the Act and, in addition, the Government Laboratory will receive the remainder of the royalties, which previous to the Act would have had to be returned to the U.S. Federal Treasury. As a result, more funds may be available for patenting and licensing activities, for promoting technology transfer, and for enhancing further research activities in the originating laboratory."

What are the typical CRDA considerations?

There are many issues to consider when developing a CRDA. The following list is derived from information in a paper entitled, Factors to Consider in Structuring a Cooperative Research and Development Agreement by Robert F. Kempf, (4) Patent Counsel, NASA.

What is the subject matter of Agreement?
Who is providing facilities and/or equipment and who can use them?
How will information, technology, or know-how be shared?
Who will conduct what R&D activities?
Who is responsible for what, and when, and where?
What are the funding arrangements? Will each party fund its own activity? (The Government cannot fund the commercial activity).
Who has title to property and who is responsible for damages?
What are the limitations on liability for both parties?
What are the intellectual property rights considerations?
What is to be made or produced by the private party and by the Federal employee?
What is to be made or produced jointly?
Will there be an exchange of rights or will the Government acquire a royalty free, nonexclusive license (for Government purposes) in exchange for a similar license to the private party?
How will situations be handled for inventions made by Federal employees?
How about rights to inventions made jointly?
How should the situation of data produced exclusively by the private party under the CRDA or before the CRDA be handled?
How about the special problems of data produced by Federal employees, recognizing that all such data are at risk under the Freedom of Information Act? Can the Government withhold from disclosure detailed design, manufacturing or process data that may be used for commercial development?

Where can I get a list of the CRDAs now in force?

As of the date of this paper there is no centralized list. We have been sent lists from Army, Air Force, NIH of DHHS, National Institute of Standards and Technology, and the U.S. Department of Agriculture. The lists are not in consistent format but we can send them to you if you contact either of the authors at (202) 696-4707.

Are there model agreements available?

Yes, there are several. The one used most often as a reference is from the Department of Commerce, Office of Technology Management.

So you are an employee of a Government owned and operated laboratory and want to start a CRDA program. What do you do?

- Get your laboratory to establish an Office of Research Technology Application (ORTA) as required by law.
- Become knowledgeable about the Technology Transfer Act of 1986, the Executive Order, and any implementing regulations promulgated by your agency.
- Find an advocate in top management who will promote CRDAs.
- Decide on the subject of the research and development for collaboration.
- Identify potential collaborators.
- Ask your legal counsel to draw up a model agreement and provide questions on legal issues including conflict of interest, intellectual property and contract principles.
- Address the various issues in your agreement.
- Prepare a research plan.
- Select a collaborator.
- If necessary, remind those who are reluctant that support of technology transfer is the law and, in fact, the law makes it a mandatory part of every scientist's and engineer's performance factors.

What are some of the major issues likely to be faced in negotiating a CRDA?

Many sources described issues faced by their agencies during negotiation. A common thread was rights to data, and patent issues. An excellent paper on the topic of issues was written by Kathy Ann Kurke, Esq., (3) Assistant Chief Counsel of Research and Development, and Robert S. Gorham, Jr., AIA of the U.S. Army Corps of Engineers. Some problems described by them are as follows:

Non-Patentable Technology: Much of the technology shared is software which is copyrightable but not patentable. The law provided for "royalties or other income the agency receives in account of any invention." Whether intellectual property was an "invention" under the law was questionable. However, Congress recently revised the Stevenson-Wydler Act by provision in the FY 89 National Institute of Standards and Technology Authorization Act. It permits licensing agreements for intellectual property.

Finding a Collaborative Partner: While laboratories are not required to follow Federal acquisition competition rules, some method of notifying potential collaborative partners of patents and inventions should be developed. A logical place to publish notices would be the Commerce Business Daily (CBD) but the CBD has refused to accept a Technology Transfer notice since it is not a procurement specifically covered in the CBD. Technical or trade journals seem to be the next best choice, as well as papers presented at technical meetings. Broad distribution of agency technical reports is effective. If the non-Federal party initiates the discussion, it can be handled similarly to the procedures defined in the FAR for an unsolicited proposal or it can be handled strictly on a one-on-one basis.

Selection: If there are more than one potential partner(s) they should all be treated identically and should be judged on the same factors in the process of selection. The Act provides little guidance in this area and there is much flexibility in establishing factors. While we can name as many factors as deemed appropriate, the Act describes at least four items that the Government should consider in making its selection. First, the effectiveness of the technology transfer. Since the primary intent of the Act is to facilitate transfer, the Government should be concerned with the plans for marketing the item. Secondly, there is a "preference" for domestic firms or firms manufacturing in the United States. Thirdly, special consideration should be given to small business firms. And finally the Government should consider benefits it will derive from the arrangement, including the potential of the royalties or other income.

Conflict of Interest Issues: In order to avoid an actual or appearance of conflict of interest, the inventor entitled to royalties should not be involved in the evaluation or negotiation of the CRDA.

## CONCLUSION

Technology transfer is the law and Congress has stressed activism in this area in PL 96-480. Some laboratories have embraced the opportunity to share their technology and their resources, and receive royalties for their laboratories and inventors while others have been reluctant to take the lead. CRDAs are not easy to execute because of the many complex issues, but agencies who are using them have found the challenge small when considering the potential payoffs.

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# TAMING THE WILD RAD--A PERSPECTIVE ON TECHNOLOGY ACQUISITION MANAGEMENT

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## ABSTRACT

Ever since the adverse effects of radiation were observed on early generation space systems, there has been a concerted effort by the Department of Defense (DoD) to develop and produce more tolerant radiation hardened (rad hard) microelectronic circuits. These circuits must be capable of reliable operation in an ambient space environment or the even more stressing environment following a nuclear conflict. Rad hard circuitry development is, at its core, a technology acquisition effort and, as with material and systems acquisition, technology acquisition is bounded by cost, schedule, and technical performance constraints. In the case of rad hard microelectronics, the technology developer is required to constantly reconcile and balance these three classic components of the acquisition equation. Further, the emergence of new electronics and circuitry within the commercial sector which are faster, less power hungry, and more highly integrated renews the pressure to develop ever more capable hardened electronics. This paper will focus on the current program to develop rad hard, silicon-based, analog and digital microelectronic circuit technology. It will contrast the approach currently used by the cognizant rad hard electronics development office within the Strategic Defense Initiative Organization (SDIO) with that used earlier. It will then discuss the following factors forming the program's foundation for success:

1) clearly established goals,

2) defined development cycle,

3) comprehensive test and evaluation program,

4) government oversight, and

5) strong lines of communications.

This paper will also touch the subtler problem of how to promote infusion of developed technology into systems and will show how the above factors help alleviate this problem.

## INTRODUCTION

The problem of developing and producing adequate, rad hard electronics is bounded by our ability to control and balance the cost, schedule, and performance elements of the management equation. How the elements relate in this effort deserve a brief discussion. The cost of typical rad hard circuits can be 10 to 100 times more expensive than their non-hardened commercial counterparts. While some portion of this cost differential can be explained by the additional, and expected R&D effort associated with the technology development, a far greater share comes from three additional elements which are typically associated with rad hard development and fabrication. First, the demand for rad hard electronics relative to their commercial cousins is small, if not minuscule; therefore, fixed production costs must be spread over a very limited production base. Next, specialized production equipment, ultra high quality materials and non-standard production steps tend to drive per wafer costs. Finally, and most significantly, since these parts are typically used in critical applications where reliability is clearly an overriding consideration, substantial per unit value is added through meeting rigid post production hardness and quality assurance requirements.

Schedule constraints push technology to attain specific performance plateaus in time to meet system demonstration and fielding requirements. As with other things, schedule acceleration although necessary can drive cost. For example, parallel development efforts which help to reduce schedule risk may significantly increase the cost of a given effort.

Finally, the need to meet even more stringent performance requirements such as reduced power consumption, increased speed, greater circuit density, and enhanced radiation tolerance necessary to the successful development of emerging strategic systems must be satisfied within the bounds of reasonable cost constraints.

## PROGRAM STRATEGY

The challenge facing SDIO was to find a way to conduct the complex business of developing rad hard electronics within the framework of the above constraints and to integrate this increased capability, once it became available, into developing systems. Prior to the establishment of the Surveillance, Acquisition, Tracking and Kill Assessment (SATKA) Program 081 (SAT 081) effort, system offices were pretty much left on their own to develop the hardened technology which would ensure mission performance. While this allowed system developers to tailor research and development specifically to their needs, it also resulted in duplication of effort and likelihood of less than desirable cost/performance tradeoffs in cases where specific program funds had not been earmarked for hardened circuit development. Also, increased capability developed for or within a given program did not always become generally available to others within the user community.

In 1984 the SAT 081 program was established within the U.S. Army Strategic Defense Command (USASDC) in Huntsville, Alabama to help resolve many of the issues attendant to rad hard circuit development and to promote better overall management of the development of this technology. To date, the move to a more centralized approach to managing this technology has proven to be a step in the right direction. For example, capability improvements of several orders of magnitude have been demonstrated in specified areas of device hardness and materials quality. As a result, circuits developed under this program are currently being targeted for both space-based and ground-based elements of the SDI system.

Program success has been based upon an approach to technology development which calls for close cooperation and intense interaction among the government, technology vendors, and potential users. As seen in Figure 1 the program is structured around three major components: (1) the government team, (2) the user, and (3) technology vendors from private industry.

The government team is comprised of personnel from numerous government organizations and laboratories, all of which have specialized expertise in the area of rad hard electronics. Further, the team is supported by recognized experts from the academic world as well as from private industry. The government team (along with all other aspects of the program) is managed out of the Active Sensors Division of the USASDC in Huntsville, Alabama. The government team performs several key functions, including strategic planning, program and budget development, program management, and technical oversight for the program in general. Also, within the government team is a multi-agency test organization which combines government-owned radiation test facilities with highly capable personnel from government and private industry to form a one-of-a-kind test organization. This test organization functions under the auspices of a Test Integration Working Group (TIWG) which is chaired by a government chairman who reports to the SAT 081 program manager. The TIWG chairman is supported by a technical chairman from Harry Diamond Laboratory, thus providing a balanced mix of managerial and technical leadership for the working group. The TIWG provides oversight for all aspects of a comprehensive test and evaluation program designed to ensure that technology goals are indeed met. Due to the complex nature of the rad hard electronics testing, a formal Test Guidelines Document (TGD) was

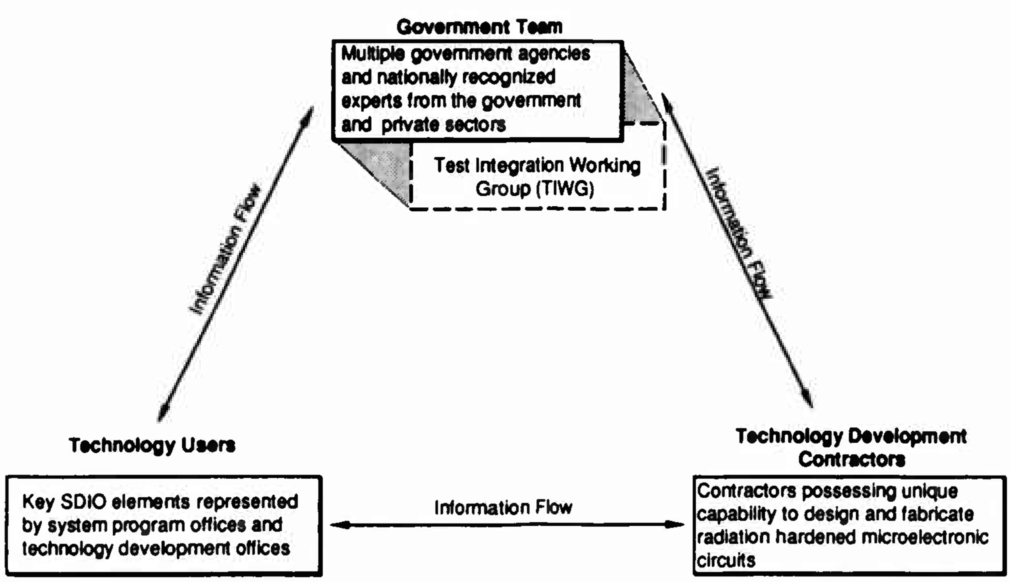


Figure 1. Major SAT 081 Program Elements

developed (and is periodically upgraded) which describes acceptable test procedures for testing activities conducted under the SAT 081 program. This document is used by government agencies engaged in actual testing or providing oversight to contractor testing as well as by the contractors themselves. The TGD, then, provides a "level playing field" for all program participants, thus making certain that performance/capability evaluations are equally and fairly applied. Finally, the TIWG provides the capability to conduct testing which goes beyond the scope of the capability/resources of individual program contractors. This allows the government to "fill in the gaps" as far as the overall evaluation of rad hard technology is concerned and, as necessary, to validate results derived from contractor testing. The test program has two key elements. The aboveground test (AGT) element represents, by far, the larger share of the entire test effort and employs the extensive use of a large array of radiation test simulators such as linear accelerators and flash x-ray machines. The underground test (UGT) element is employed for those tests where fundamental test issues cannot be adequately addressed by AGT simulators. This unified test and evaluation program conducted under the auspices of the SAT 081 program is expected to have significant impact in promoting the insertion of technology into emerging SDIO systems by demonstrating the achieved maturity of the hardened technology.

The second major component is the user. In this case the user is represented by major program offices within SDIO such as Boost Surveillance Tracking Satellite (BSTS), Space Based Interceptor (SBI), Exo-Atmospheric Reentry Vehicle Interceptor Subsystem (ERIS) and, as appropriate, systems developers from private industry. Close coordination must be maintained to ensure that the technology development program efforts are consistent with ultimate systems requirements. While the requirement for close interaction between user and developer can, at times, severely strain program personnel resources, such coordination is clearly essential to program success.

Private industry technology contractors form the third component of the SAT 081 program. This component is comprised primarily (although not exclusively) of integrated circuit (IC) foundries possessing the equipment and technical skills necessary to produce rad hard integrated circuits. Beyond the technical skills, one of the essential characteristics each of these contractors must possess is the willingness to work closely with the other elements of the program, especially the government team.

## KEY FACTORS FOR SUCCESS

Success rests firmly on five key factors which, while not necessarily unique to the SAT 081 program, form the philosophical foundation upon which the program rests. Those factors are

1) clearly established goals,
2) defined development cycle,
3) comprehensive test and evaluation program,
4) government oversight, and
5) strong lines of communications.

Each of these factors will be addressed in the ensuing paragraphs.

### Clearly Established Goals

The goals for the SAT 081 program respond to three objectives. First, they define realistic, threat environment hardness levels capable of meeting all anticipated ground-based and space-based systems requirements. To accomplish this, two different hardness levels (Level 1 and Level 2) were established. Further, within each level, six hardness categories were also established corresponding to the following phenomena: dose rate upset, dose rate survivability, total ionizing dose, x-ray survivability, single event upset, and neutron damage. The establishment of dual hardness levels and multiple hardness categories was necessary if SAT 081 were to respond to varying hardness requirements unique to individual system elements within SDIO. By setting two succeeding levels, the program manager is able to provide system users the flexibility to tailor selected component hardness levels consistent with system requirements. This dual level approach also had the added advantage of providing a growth path which supported a logical stepwise development of the technology in question. Next, the goals were designed to "stretch" the capability of technology vendors, thereby ensuring that gains in our industrial base wrought under the program justified the necessary investment of national resources. This idea of "stretching" also helps guarantee that sufficient margins exist between the capability that is needed and that which is available. Finally, the SAT 081 goals provide a clearly defined "measuring stick" by which contractor performance can be gauged within the program. Obviously, these goals provide the baseline for all testing conducted under the program.

### Defined Development Cycle

From the onset, SAT 081 has worked to capitalize on hardening advances made under other Department of Defense programs such as the Very High Speed Integrated Circuit (VHSIC) Program launched in 1979. Building upon this established capability, the SAT 081 government team works with the technology contractor to carefully design a test chip suitable for evaluating the ability of a given contractor's technology to meet the range of hardness requirements identified in preceding paragraphs. By employing the test chip design and iterating through a series of build-test-build cycles, the technology contractor is able to systematically refine both circuit designs and manufacturing processes for the purpose of attaining desired hardness levels. Attaining and verifying desired hardness goals through the use of test chips does not, however, complete the task. In order to initiate the move from the realm of technology development to applied technology, circuits are identified which have strong potential to fill recognized system needs; these are termed demonstration circuits. Demonstration circuits, typically, will be selected based upon their potential for having broad based system applications. Once selected, specifications for these circuits are defined in close cooperation with the user community. Thus, a strong potential for these circuits to be employed in large numbers by several different SDI elements is a key factor in the demonstration circuit selection process. This helps the SAT 081 program avoid acceptance/insertion problems experienced by other technology development undertakings. Final verification of the developed technology rests squarely on the demonstrated performance of these circuits.

Comprehensive Test Program

As discussed above, the SAT 081 test program is a key element of the overall effort. Through the TIWG, recognized experts have been identified for each of the established hardening categories. The function of these experts is to provide specialized test support to all program participants within their area of influence. The area experts work closely with each of four separate lead laboratores (see Figure 2) which have also been established under the program. Lead laboratories are nationally recognized DoD labs such as Harry Diamond Laboratory (HDL), Naval Research Laboratory (NRL), Naval Weapons Support Center (NWSC), and Rome Air Development Center (RADC) which are charged with planning and overseeing the testing and verification of specifically defined rad hard technology efforts. By working in conjunction with other lead laboratories and the area experts, requisite skills and resources are made available which enable each lead laboratory to execute its testing mission. Two advantages evolve from the lead laboratory/area expert concept which should be noted. First, both the lead laboratories and area experts are from the government sector; this helps to ensure that each technology effort is given thorough, objective evaluation. Next, the ability to respond to unforeseen or newly discovered phenomena exists as an integral part of the overall program.

Government Oversight

Direct government oversight, supported by the expertise within the government team, ensures that progress for each of the program elements is carefully monitored. Through the use of technical reviews with each of the technology contractors, pitfalls and blind alleys which lie on the development path can be identified by the government. Finally, dedicated technical and contractual oversight allows the government to focus and refine overall contract efforts consistent with changing program priorities.

Communication and Coordination

Owing to the diverse, highly interrelated, technical nature of the SAT 081 program, the ability to communicate and coordinate clearly and effectively may transcend all of the previously mentioned factors in terms of importance. Within the program, information flow is maintained through a series of program reviews, technical reviews, briefing presentations, working group meetings, meeting minutes, schedules, plans, trip reports, and technical letters. None of these is unique in and of itself. What is unique is the premium which program management places upon maintaining strong

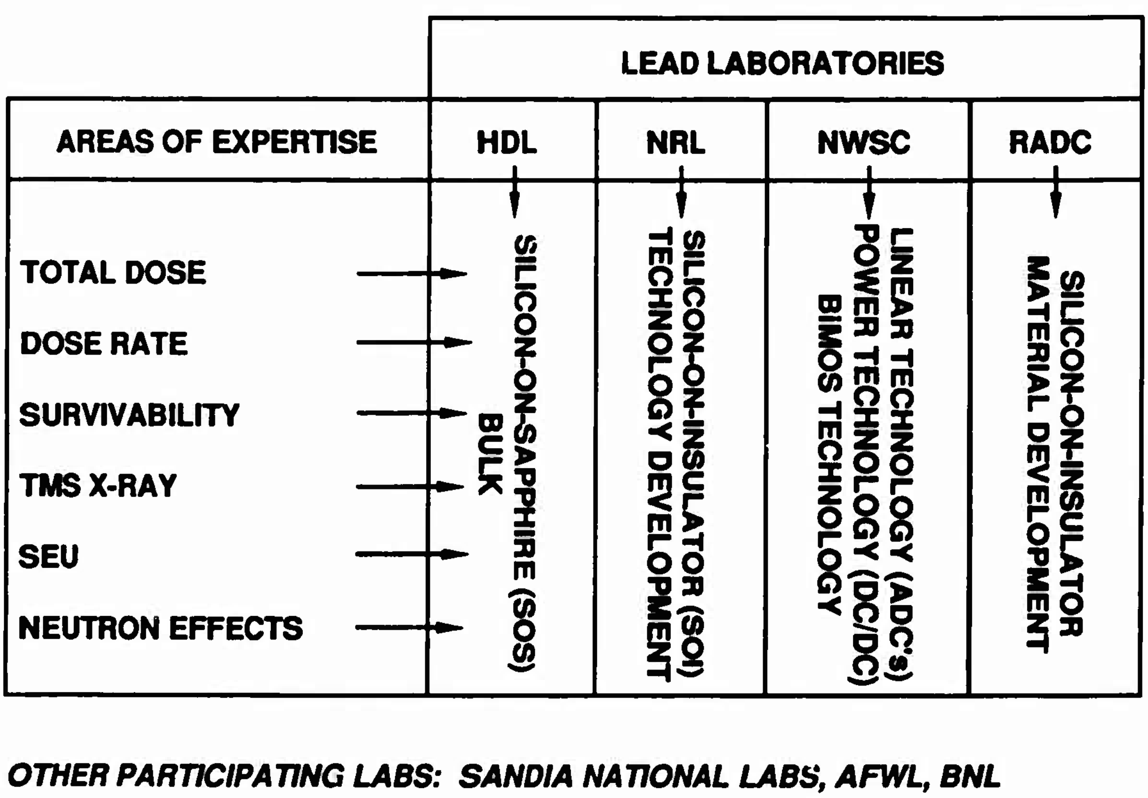


Figure 2. Lead Lab/Phenomenology Matrix

lines of communications, both internally and externally. Merely recognizing the need to coordinate closely with other elements is not sufficient; rather program personnel must be willing to expend the time, effort, and energy which guarantees efficient information flow within the program. Having done this, the SAT 081 program is able to remain focused upon near term priorities; respond rapidly to changes which impact upon its technology development role; and position itself to meet the technology demands of the future.

## CONCLUSION

The information contained in the preceding paragraphs indicates that technology development, in a very basic sense, is an acquisition process. As such, technology development programs exist within the clear constraints defined by recognized cost, schedule, and performance parameters and respond to various stimuli in much the same manner as other acquisition programs. The SAT 081 program is no different. Over time five factors have emerged which have done much to form the basis of success enjoyed by this program. Reliance on these factors has enabled SAT 081 to meet technology performance goals while ensuring rad hard electronics are available to the user consistent with system needs. Finally, the similarities between technology acquisition and material acquisition suggest that factors identified in this paper may have much broader applicability within the acquisition community in general.

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# AUTOMATION

AUTOMATION OF THE ACQUISITION PROCESS USING LIFE CYCLE MANAGEMENT (LCM) METHODOLOGY

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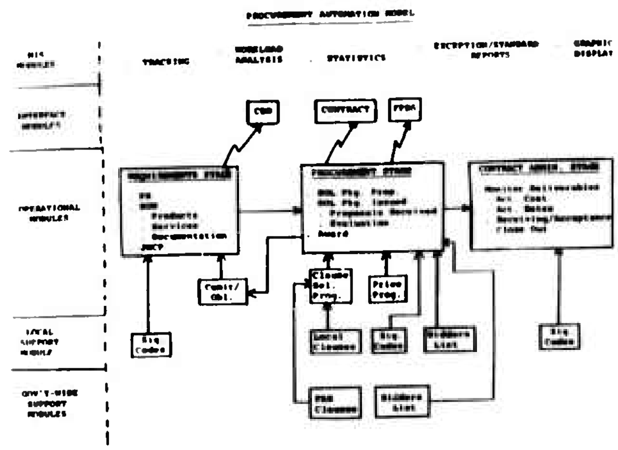
ABSTRACT

Development of automated acquisition systems throughout the Federal Government has not complied with Life Cycle Management (LCM) concepts, which require analysis and documentation of generic user needs. Hundreds of systems or partial systems have been developed, which either lack documentation, automate only pieces of the acquisition process, or contain duplication of effort. As a result, systems do not fully meet the operational and management needs of the agencies and cannot be shared among agencies. Agencies need to develop integrated systems which look at the acquisition process as a whole.

This paper provides a summary of the Bureau of Land Management's (BLM's) efforts to document generic user needs in the system analysis stage of the LCM process. Recommendations will be made on use of the "detailed user requirements document" for use as a model in a Governmentwide effort to develop and document data standards which are based on federal procurement user needs.

INTRODUCTION

Since paperwork in the federal procurement process is very burdensome throughout Government and Industry, there have been several automation initiatives resulting from Executive Order 12352 on Federal Procurement Reforms, Reform 88, and the Paperwork Reduction Act, to the latest emphasis on Electronic Data Interchange (EDI). The Federal Procurement Automation Council (FPAC) developed an excellent procurement automation model. The model envisioned automating the entire acquisition process in an integrated fashion with the Federal Procurement Data System (FPDS), workload analysis, tracking and the like, as by-products of the system. Although development of the model was a good first step, we are not aware of any




Governmentwide effort to document generic user needs and detailed requirements using LCM guidelines. Since the technology is available to the procurement community, there have been a proliferation of hundreds of systems on tracking, reporting contract writing, purchasing and the like, which duplicate each other and are not transportable. Meanwhile, a study required by Section 10 of the OFPP Act Amendments of 1988 (P.L. 100-679) is being conducted to determine the adequacy of the data in the FPDS for the management, oversight and evaluation of Federal procurement. Although the FPDS is useful in providing after-the-fact data on contract awards concerning the extent of competition small business utilization efforts and the like, it provides very little information before decisions are made because the acquisition process is not automated. Also, since it is not computer generated, collection of the data for the report adds to the paperwork burden because most of the data is generated by completing handwritten computer forms or by separate keypunching by procurement or data entry personnel. Much of the information is inaccurate because it is not computer generated from source documents used earlier in the procurement process (i.e., requisitions, bidders lists, solicitations, contracts, purchase orders (PO's), modifications to contracts and POs, receipt and acceptance data). If we focus our attention on standardizing the data for doing the purchases and contracts from requisition to closeout, we will have access to a standardized data base of several hundred data elements for management oversight and evaluation of Federal procurement. Most of the data and processes are already standardized in the Federal Acquisition Regulations on Standard Forms 18, 26, 30, 129, 1442, OF 347, in solicitation/RFQ provisions, contract/PO clauses and the like.

TEXT OF PAPER

The BLM examined numerous "cradle-to-grave" systems that could possibly meet our needs, but none of them had documented their requirements using LCM guidelines. Therefore, we were forced to go through a very labor intensive effort with our already overburdened procurement personnel and ADP systems analysts at all organization levels to document our procurement needs in a generic fashion using standard forms, standard processes, clauses and data from the Federal Acquisition Regulations. This includes generic data flow diagrams, process narratives and data element descriptions to show how the data element dictionary was developed. The 2-1/2 year effort equates to approximately $225,000 in federal personnel salaries and travel costs to develop a current system description, a user needs document and a detailed requirements document for the Bureau's Automated system for Acquisition Processing (ASAP). ASAP's generic requirements call for an integrated system covering all common procurement functions from requisition to close out. The system will consist of four major modules: requisitioning, solicitation, award and administration. It covers contracts and small purchases.

The data will be keyed only once from source documents into the system by requisitioners, procurement personnel, Contracting Officer's Representatives (CORs) and other personnel responsible for inputting data into the process, thereby eliminating the need for rekeying and reediting. If the data is incorrect, the responsible person must amend the requisition, bidders list, solicitation, contract, purchase order or other formal document in the process. Preprogrammed or "ad hoc" management reports can be obtained from a data base of several hundred standard data elements which should be nearly 100 percent accurate. The majority of solicitation provisions, contract clauses in the uniform contract format or purchase order clauses can be automatically generated by "designators" from data elements on standard procurement forms such as contract type, dollar amount, product service code, SIC code, etc. Then, only a few questions need to be developed for specific contracts. We expect our ASAP project to link commitment data on the requisition, obligation data on the contract or purchase order, and receipt/acceptance data to the Federal Financial System. We also expect to connect ASAP to our Automated Property System, the FPDS and several external data bases such as the FAR, the CBD, etc. We will also use generic data transmission standards such as ANSI X12 so that it can be transported to other agencies and used to meet their basic needs.

Using the ASAP Detailed Requirements Document as a benchmark, a request for information was issued to seventy-five (75) vendors interested in procurement automation. Eighteen (18) vendors responded. Sixteen (16) of the vendors were visited to discuss and view their automated procurement systems or concepts for procurement automation. Several Government agencies were also visited to discuss and view their systems. As a result of these visits, no existing automated procurement system was found which would fully meet the ASAP Functional Requirements without major revisions.

Recommendations:

- Under the sponsorship of the the Federal Procurement Automation Council, standardize the data for automation of the acquisition process using BLM documents as a model since they were developed using LCM methodology and they are generic enough to meet basic procurement operational and management needs. Merge the federal specific procurement data elements with industry's electronic data interchange (EDI) data elements. [Please note that much of the information in the BLM detailed user requirements document, including the data flow diagrams of the processes, is on "EXCELERATOR CASE tool" systems engineering software.]

- After the common data base is established, develop interface requirements for the FPDS's 45 data elements for automatic generation of the report from source documents in the acquisition process. (Presently, most reporting data for the FPDS has to be keyed separately into the system at time of award, rather than automatically generated from a data base of several hundred data elements that were already keyed in when the requisitions, bidders lists, solicitations and award documents were generated prior to the award.)

- Since BLM has completed the system analysis stage in the LCM, we need to proceed quickly with system design. We solicit opportunities for joint partnership ventures with agencies who may have already developed a similar system, or who have the resources and experience in designing integrated acquisition systems, to reduce duplication of efforts and share critical procurement and IRM resources. We request that interested agencies contact either Larry Keller, the ASAP project manager in Denver, CO at FTS 321-6505 or Commercial (303) 236-6505 or Joe Federline, Procurement Chief in Washington, D.C., at (202) 343-4843.

CONCLUSIONS AND SUMMARY

With a standardized automated acquisition process, we would certainly reduce the paperwork burden in the process for both Government and industry, provide better procurement service to our clients, and have access to a much larger data base for management oversight and evaluation of procurement operations at all organization levels. We feel we have made an excellent start by developing generic detailed user requirements for automating the acquisition process. However, there needs to be Governmentwide cooperation with upper management commitment and funding to make it work so that all who work with, or are associated with, the acquisition process can realize the full benefits of an integrated automated acquisition system without needless duplication of development efforts.

## AVAILABLE DOCUMENTS

(1) Project Charter and Mission Needs Statement for the Automated System for Acquisition Processing (ASAP), dated January 7, 1987.

(2) ASAP User Requirements Document, dated February 2, 1988.

(3) ASAP Detailed Requirements Document, dated May 31, 1989.

COMPUTER SIMULATION MODELING FOR HIGH LEVEL MANAGEMENT OF MISSILE PRODUCTION PROGRAMS

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ABSTRACT

Missile program managers have several specific, recurring problems which may be addressed through computer simulation. These problems include determining:

- Effects to the program of changing production quantities
- Effects of "speeding up" or "stretching out" the program
- Effects to program of plant modernization
- Expected ECO/ECP processing times and
- Overall quality performance.

Simulation can also assist in performing producibility analyses. Most present analytic approaches rely on static models of the acquisition environment. Monte-Carlo simulation, however, provides a means of relaxing the assumptions of static models. TASC has developed, through internal research and development, a missile production simulation model which addresses these concerns for porgram managers.

INTRODUCTION

The Analytic Sciences Corporation (TASC) has provided analytic support to many missile programs, including Trident, Aim-9, Stinger and the Advanced Cruise Missile. TASC has perceived the need among missile program managers for improved tools to perform basic production related assessments. As a result TASC decided to research methods of addressing missile program managers' needs through computer simulation using Monte-Carlo methods.

Defining the problems to be addressed through simulation is the most important step in the simulation effort. Clear problem definition provides a sound basis for model development and tailoring of model outputs to specifically address this set of concerns. The most significant deficiency in many simulation efforts is attempting to create a model without a clear set of objectives. The lack of a clear set of objectives at the outset of the project will result in a model which provides poor output data.

Important in any modeling project is the identification of the states of the processes to be modeled. Many processes may be modeled as discrete events along the time continuum, i.e. assembly of parts at one station which are then passed on to a subsequent station. Other processes are continuous, such as drying of paint. It is therefore necessary in a simulation model to a use the appropriate functions, either discrete or continuous, determinant or stochastic to represent associated processes.

The statistical behavior of the total production system may or may not be apparent during the modeling stages of a project. A current system may be stable and have well identified properties and states, whereas a proposed or new system must rely on estimates for model input. An important consideration for modelers is the attainment of steady-state by the system random variables. A production system which reaches steady-state will have "well-behaved" output variables which will tend toward their respective means. A non-steady state system, however, will require a greater number of model replications to develop stable output statistics and is likely to be more sensitive to initial conditions and random number streams than one which attains steady-state. Translated into practice, a nonsteady-state manufacturing system will be more difficult to predict and assure on-time, quality deliveries.

Modeling methods available for manufacturing systems include not only the use of discrete and/or continuous system components, but methods of running the simulation as well. Also, many types of output variables, and aggregation of statistics must be considered. In the modeling of a depot facility, for example, the units' arrival for service is itself a stochastic variable. In the manufacturing of major pieces of military equipment, however, the lot order times are determinant, but the number of units may be stochastic, depending on the probability of a given level of funding. The depot model would require a structure based on a continuing stream of stochastic arrivals, whereas the equipment manufacturing model requires a determinant number of lot orders with a definitive end to the program. The two possible run methods for these cases are:

- Regenerative for the depot facility and
- Terminating for the manufacturing model.

Output variables may reflect counts, states, or continuous measures. Aggregation is the process of using a single statistic to represent a group of functions. An example of aggregation would be the modeling of a manufacturing area by an aggregate statistic such as "processing time" and not modeling each individual function performed in the area. Aggregation is especially important for high-level models.

Validation of the simulation model is a crucial step in the simulation effort. Yet it is often neglected. Defining problems to be addressed by the model early in the project and tailoring the model to those problems, will facilitate defining validation procedures and the overall model validity will be improved. High "face value" validity of the modeling assumptions is important in model validation. This needs to be followed by testing the assumptions, where possible, and testing code segments. The final product must be tested as well. Initial estimates for the production system may be used in the validation process, as well as analytic queuing results. These may be compared to output to assess "reasonableness".

## METHOD

A production paradigm, shown in Figure 1, was created for a general missile prime contractor using data accumulated through studying several ongoing missile systems. The paradigm concentrated on operations which were expected to be performed in the prime contractor's facility and dedicated to a specific missile program. The model also included the capability for assessing expected quality levels and relative costs. The contractor was given a set of shops for in-house production or integration of "parts". The prime contractor also received "items" he purchased (i.e. subsystems such as electronics packages), government furnished equipment (GFE) and "raw materials" for in-house fabrication operations. The example use of the model in this paper is to illustrate the use of simulation to support analyses of buying strategies and alteration of contractor capacity.

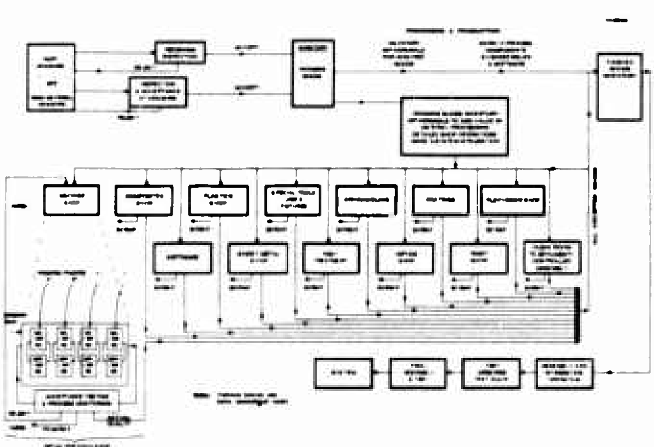

Figure 1 Production Paradigm

The simulation model, reflecting the paradigm in Figure 1, was created in the SIMAN™ language. This meant that individual parts, purchased items, raw materials and government furnished equipment flowed through the shops and areas shown in the figure. The specific focus of this example was to assess the effects of:

- Differing total program production quantities and
- Effect of changing the material processing resources.

Each shop, assembly, test and quality control area was defined as having a set of "resources" which together represented the overall capability for the area to handle concurrent processing. A cost index was created to allocate cost based on shop time and quality. The model was used to "manufacture" each missile in an example missile program.

™SIMAN is a trademark of Systems Modeling Corp., Sewickley, PA

Data to create and simulate the example missile program was provided from several ongoing missile programs. The representative missile was composed of:

- Five purchased items
- Two pieces of government furnished equipment and
- Seven parts fabricated by the prime contractor using
- Three types of raw material

Aggregate statistics were developed for each of the individual shops visited by the parts during the simulation. This resulted in both part and system cost indices. A total of 130 system random variables were used in the simulation. The delphi method was used to validate the simulation outputs.

The simulation was run as a terminating simulation. The simulation ended when programs of 500 and 1000 missiles were completed. Five different lot buying stategies were investigated. The lot purchasing stategies are presented in Table 1. Lot quantities were doubled to highlight differences due to volume change, as opposed to pattern change. Five replications were made of each lot buying strategy, for a total of 25 replications. The time between lot orders was constant at 2.5 months. The production system state at the start of each replication was "empty and idle". Upon completion of the last missile in the replication the production system was again "empty and idle".

Table 1 Lot Purchasing Stategies

| NUMBER OF LOTS | 500 MISSILES LOT SIZES | | | | | | | | 1000 MISSILES LOT SIZES | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 4 | 50 | 100 | 150 | 200 | | | | | 100 | 200 | 300 | 400 | | | | |
| 5 | 100 | 100 | 100 | 100 | 100 | | | | 200 | 200 | 200 | 200 | 200 | | | |
| 6 | 25 | 50 | 75 | 100 | 150 | 100 | | | 50 | 100 | 150 | 200 | 300 | 200 | | |
| 7 | 50 | 75 | 100 | 125 | 75 | 50 | 25 | | 100 | 150 | 200 | 250 | 150 | 100 | 50 | |
| 8 | 50 | 50 | 50 | 50 | 100 | 100 | 50 | 50 | 100 | 100 | 100 | 100 | 200 | 200 | 100 | 100 |

## SIMULATION OUTPUT ANALYSIS

Example outputs of the simulation include the times required to complete the entire program of missile buys for 500 and 1000 missiles. Figure 2 presents the mean times required to complete the total buys as a function of the number of lots in the program. Time is expressed in months. The minimum mean completion times for both sets of programs occurred when the missiles were ordered in five lots. The maximum mean completion time for the 500 unit program ocurred when missiles were ordered in 8 lots. The maximum time for the 1000 unit buy program occurred at four lots.

The type of data presented in Figure 2 can have a significant impact on program management. It shows a program manager when his buys should be completed based on the five buying patterns. Since the delivery times were developed from variables representing the behavior of the production system, there can be considerable confidence in the information. The graphs represent dynamic system behavior, not manipulation based on an a priori due date. The results of the simulation can be compared to requirement dates to choose the best overall solution to the question of buying strategy.

Further analysis indicated dependency of the Machine Shop on the Composites Shop. This suggested that the Composites Shop was a bottleneck to production. In an analysis of the part flows used in the model it was apparent that the Composites Shop fed a substantial amount of its production to the Machine Shop. Therefore, the bottleneck occurred at a source for parts. This suggested that there were several courses of action could be taken to better utilize facilities. These actions would be to:

- Increase available processing resources in the Composites Shop to increase total throughput capability

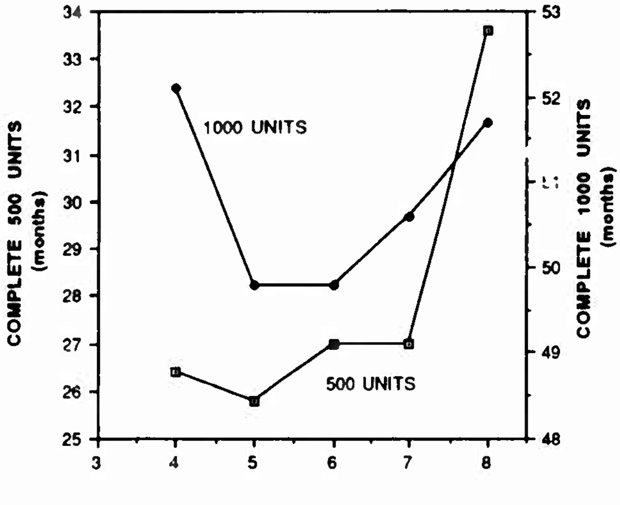


Figure 2 Mean Time to Complete Total Missile Purchase

- Decrease the processing resources available in the other shops
- Modernize production machinery or
- Increased efficiency of transportation.

Assuming that one of the program goals is to produce the buys as quickly as possible, increasing the resources available in the Composites Shop was chosen. The model was then used to evaluate the effects of this strategy.

As a consequence of the apparent bottleneck through the composites Shop, the model was altered to increase the available resources in the shop by 10%. The model was then rerun for the 500 missile program buy scenarios. These runs showed differences not only in shop utilization, but finishing times as well. Figure 3 shows the differences in finishing times for the original program and the program using the revised Composites Shop. Five lots remained the best strategy for purchasing the missiles. Without the bottleneck the last missile was delivered approximately two months earlier. Shop utilizations also improved in the second set of runs.

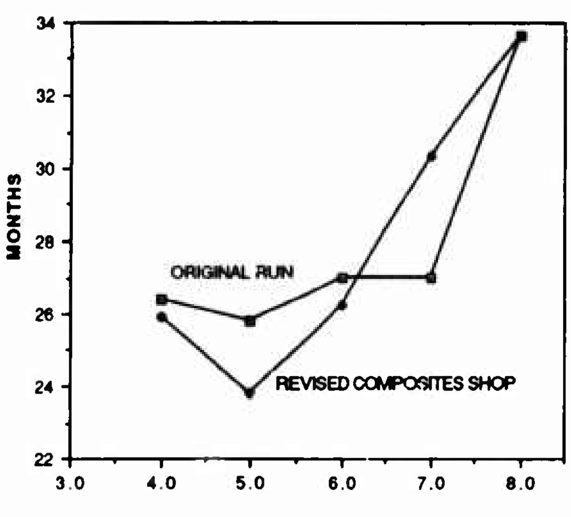


Figure 3 Comparison of Missile Buy Completion Times

The outputs from the simulation runs were shown to provide useful data to program management in two specific areas. The first was completion times for the total program buys. Unlike static production rate models this production model used Monte-Carlo simulation to develop estimates based on the production system dynamics. Second, the model was useful for examining the facility and determining a possible means of alleviating a bottleneck and thereby reducing the time to complete the program. In this example the bottleneck was relieved by increasing the throughput capacity for the Composites Shop. This gave high-level management the ability to make a preliminary determination of where limited financial resources might be allocated to improve the contractor's throughput.

## CONCLUSION

Simulation can provide missile program managers with a tool for analyzing ongoing changes in a program. Sensitivity analyses are readily performed and the effects on important programmatic variables determined. In addition to the two areas presented in this example, the simulation model can be used to assess the effects of system changes on product quality and a relative comparison of cost can be made between alternative scenarios. The effects of ECO/ECPs may also be assessed using this model. ASC's missile production simulation model requires tailoring in order to be valid for a specific program, however this effort results in improved decision making in the program office.

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DOD PROCUREMENT AUTOMATION AND INFORMATION SYSTEMS
-- THE EMERGENCE OF CONCEPTS AND APPLICATIONS

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ABSTRACT

The lack of adequate information flows to the contracting office may be one of the most significant systemic deficiencies in the DoD acquisition process. With the increasing burden of regulations, procedures, audits and oversight reviews, it is important that the contracting officer, as a key decisionmaker in the acquisition process, have optimum access to procurement information for decisionmaking and operations management. Advancements in information systems technology have occurred which have the potential to revolutionize procurement operations and decisionmaking. Advanced office systems exist which can virtually automate the tedious document assembly and drafting process. More importantly, electronic data interchange networks have been developed which allow access to a multitude of databases and provide for paperless communication among functional offices and between buying activities and contractors. A number of systems have been independently developed within DoD which demonstrate a significant potential. However, many of these systems have been developed in an ad hoc fashion with little prior research and planning. Better DoD-wide coordination is beginning to occur which will help exploit the full potential of the emerging technology. As improved automated system capabilities are developed and tailored for contracting operations, significant gains in efficiency, effectiveness, and productivity can be expected throughout the acquisition process.

INTRODUCTION

Throughout the past decade of high-level defense acquisition studies and policy reform initiatives, there has been a surprising lack of visibility on a critically important area of the acquisition process -- contracting office operations. The lack of adequate and timely procurement information flowing to the contracting office may well be one of the most significant systemic deficiencies in the entire process. In examining why past ad hoc studies and acquisition improvement initiatives have not been sufficient, Mosier makes note of the lack of adequate knowledge and information aids for assisting acquisition professionals in effectively performing their jobs. [1] Contracting is a core function of the defense acquisition process and one which is highly vulnerable to public perceptions of mismanagement. The peacetime contracting process has become a myriad of economic, social, political, and industrial base policy agendas with the contracting officer playing a key official role. The growing complexity and responsibilities of this function requires that more effective means of information flows to the contracting officer be developed. Past procedures have been far from adequate.

Most contracting office operations within DoD have taken advantage of the capabilities offered by desktop PCs, and word processing and spreadsheet software packages which began to emerge in the early 1980s. These applications provided significant improvements over the previous centralized typing pools and tedious manual calculations of negotiating positions. The evolution of PC-based technology has not slowed. Recent advancements in such areas as database networks and telecommunication protocols have produced powerful online interactive systems for supporting complex management decisions and processes. In advancing the concept of "electronic contracting" as the future direction of procurement automation, Drake states:

"Electronic contracting brings together paperless processes, expert systems, and electronic data interchange (EDI) techniques at a microcomputer work station on the contract manager's desk. The work station provides immediate access to information through computer networks, and helps evaluate that information through customized programs with a minimum of paper transactions. Everything required for contract management is electronically available at the workstation". [2]

## TECHNOLOGY APPLICATIONS

Three distinct areas of technology have advanced to form the current state-of-the-art in information systems:

1) Powerful microcomputer hardware based on faster microprocessor chips and operating systems, and greater memory and data storage.

2) Integrated 4th generation menu-driven software oriented towards the end user.

3) Advanced architectures and protocols for electronic data interchange (EDI) networks and system connectivity.

Advancements in computer technology are currently far ahead of applications being employed in DoD contracting offices. This lag, however, may provide a beneficial opportunity for the DoD contracting community to systematically assess where it stands relative to the emerging technology. Some of these potential applications include the following:

Advanced Office Automation Systems -- Already employed to some extent, office automation technologies still offer significant potential for improving procurement operations. Local Area Networks (LANs), electronic mail, forms generation, interactive graphics, and optical disk storage are some examples which have unique applications in the contracting office. Electronic mail networks have particular usefulness in the paperless transmission of requirements documents and approval coordination within a buying activity.

Integrated Database Networks -- Such networks allow for instant online access to the multitude of cost, audit, financial, technical, and program databases which exist throughout DoD. This reduces the need for voluminous printed material. Current Database Management System (DBMS) software allows for easier ad-hoc queries and searches of various databases.

Online Vendor Communications -- While local electronic mail systems provide for paperless transmission of documents in-house, the same concept allows for linking Government buying activities with vendors and other agencies for the electronic transmission of synopses, solicitations, bids, proposals, and payments. Also, market research can be conducted through commercial networks and information exchanges to be more responsive to the requirements of the Competition in Contracting Act.

Online Regulatory Guidance -- The tremendous growth and constant change of procurement regulations has surpassed the utility of printed media to provide current guidance. Commercial systems are presently available which provide online access to the latest updates of the Federal Acquisition Regulations (FAR), DoD and local FAR supplements, and citations and texts of required contract clauses. Such clauses can be automatically assembled into contracts as needed.

Interactive Training and Consultation -- Procurement training has been identified as a major weakness in the acquisition process. [3] Contracting professionals can benefit from using interactive electronic bulletin boards to request advice on various problems and issues. Also formal courses and management simulation packages could be developed for such applications.

Decision Support Systems -- Using the concepts of expert systems and artificial intelligence, sophisticated computer applications can be developed to answer what-if questions regarding complex procurement decisions and scenarios. Such applications are particularly useful for major weapons procurements where numerous program variables and resource constraints exist.

In order to have maximum effectiveness for procurement operations, the above applications must center specifically on the needs of the contracting officer. Many DoD automation systems currently in place focus on management reporting for program or financial tracking purposes. Of the 53 systems evaluated in a recent Logistics Management Institute report, less than a third are oriented toward the contracting community as the primary user.[4] Those that involve contracting tend to be management reporting systems to track procurement milestones or to manage high volume/low value purchasing operations. Most of these systems stemmed from command-level initiatives to reduce delays in procurement administrative leadtime (PALT). All too often, input from the procurement community in designing these systems is less than it should be.

## CURRENT DOD SYSTEMS

Current shortcomings notwithstanding, the Services, defense agencies, and component offices have proceeded to develop a number of different systems which substantially contribute to the overall DoD experience base for procurement automation. A careful examination of these systems -- to include lessons learned -- is essential in successfully deploying future systems. Some of the more significant examples are described below:

DPACS (DLA Pre-Award Contracting System) -- DPACS was prototyped in 1986 at the Defense Industrial Supply Center in Philadelphia, PA., to automate a large-scale supply purchasing operation. DPACS provides a capability for retrieving price histories and other purchasing information required by buyers on solicitation. Procurement action chronologies, rotating vendor mailing lists, and contract clauses are available online. Online help and buyer assistance features are also included. DPACS will soon incorporate expanded EDI features to bring vendors online for solicitations, amendments, inquiries, and bids, and purchase orders.

POPS (Paperless Order Placement System) -- POPS was initiated in 1983 at DLA's Defense General Supply Center in Richmond, VA., to electronically place orders with established vendors for standard supply items. The system consists of a simple microcomputer network using modems and commercial telephone lines installed at three of DLA's six supply centers and 28 vendor sites. The system handles $40 million of DLA's $11 billion in annual contract awards. DLA estimates that the system will save $19 million annually in administrative costs.[5]

MOCAS (Mechanization of Contract Administration Services) -- MOCAS is the primary mainframe-based system for tracking the status of contract administration at DLA's Defense Contract Administration Service (DCAS) sites. Contract payments, performance, quality assurance, and property management functions are the principle features. A new workstation module is being planned which should make the system more useful to administrative contracting officers by adding desktop information retrieval capabilities. such as ad hoc information queries.

IPS (Integrated Procurement System) -- IPS is a planned integrated enhancement to the Army Materiel Command's (AMC) overall acquisition and logistics planning system used by the subordinate commands for major weapons acquisition. IPS is expected to replace the current contract drafting system PADDS (Procurement Automated Data and Document System). Fielding is planned in phases, from 1990 to 1992, with eventual installation at six subordinate command sites. IPS features include; 1) electronic transmission of requirements and procurement documents within the command matrix, 2) database accessing for technical information and contractor performance data, 3) support for developing independent Government cost estimates, 4) support for preparing Justification and Approval (J&A) and business clearance documents, and 5) electronic transmission of synopses, solicitations, proposals, and contracts. The system will tie in with the CCSS AMDAHL 5890 or IBM 4381 mainframe computers, and utilize Sperry 5000 /80 minicomputers and PCs on a local area network.

SAACONS (Standard Army Automated Contracting System) -- SAACONS was developed in response to the Army's need to increase productivity and standardize procedures at 261 installations worldwide. Approved as a major Army information system acquisition in 1987 and assigned a dedicated program office, SAACONS has been fielded in over 150 installation contracting offices. It is functionally oriented towards the desktop preparation of contract documents and reports by contracting specialists. The system is menu-driven and features an online clause retrieval and print capability, document assembly, word processing, and forms generation. SAACONS is primarily designed for nonmajor systems and installation level support contracting, however, a large contract module is included. Significant productivity improvements have been attributed to SAACONS, including documented decreases in PALT, as well as reductions in employee overtime and sick leave. The system uses either a UNISYS 5000/80/95 minicomputer with a UNIX operating system or a network of Intel 320 microcomputers in a XENIX operating environment at each site.

APADE (Automation of Procurement and Accounting Data Entry) -- Maintained by the Navy's Fleet Material Support Office, APADE is designed to improve management of the high volume purchasing operations at the naval supply centers, shipyards, and regional contracting centers. The system features online retrieval of price histories and vendor sources, action status, forms and report generation, and standard item descriptions. Desktop contracting support is being addressed in the most recent APADE enhancements, which include word processing, document preparation, automated bidders list, and bid evaluation packages. Currently, APADE is in operation at 15 of the planned 35 sites. Tandem TPX minicomputers using Tandem's Guardian operating system are used to service a network of desktop IBM PCs.

BCAS (Base Contracting Automated Sytem) -- While the Army's SAACONS is oriented towards contract document preparation, The Air Force's system for installation contracting, BCAS, emphasizes the electronic transmission and validation of requirements, history data, reports generation, and updates back to requiring and finance activities. While BCAS' interoperability with other systems is impressive, its document preparation system is currently limited. BCAS operates at over 120 sites and has been adopted by the Marine Corps and Defense Mapping Agency. The system uses Wang VS 85/100 minicomputers and peripheral hardware.

AMIS (Acquisition Management Information System) -- AMIS was developed by the Air Force Systems Command to provide integrated financial status tracking and administration of major systems and related contracts. AMIS subsystems also allow for the preparation of solicitations and contract documents with word processing and automated clause and price history data retrieval. AMIS is a mainframe oriented system with a significant reliance on batch and distributed processing. A NAS 8063 mainframe and various minicomputers are used in supporting 38 AMIS sites.

CDMS (Contract Data Management System) -- CDMS is planned for the 1990s as a modernization of a variety of outmoded automation systems within the Air Force Logistics Centers. CDMS comprises an ambitious, totally electronic approach for receiving and processing procurement requests, document preparation, proposal evaluation, price history retrieval, report generation, and extensive system interconnectivity. Although not operational, CDMS might well represent the conceptual state-of-the-art in procurement automation systems; Artificial intelligence applications are planned in later upgrades.

Unfortunately, CDMS is part of a costly overall AFLC system modernization program of which affordability and cost growths are major congressional concerns. [6]

## PROBLEM AREAS

A review of the various systems currently in operation or under development highlights a number of different problem areas; 1) Failure to address unique needs of the contracting community, 2) Poliferation of non-standard and non-interoperable systems, 3) Over-centralization and standardization of systems which need to be flexible, 4) Excessive program cost and cost growth, and 5) Lack of management coordination on requirements, design concepts, and assimilation of lessons-learned.

Failure to Address Contracting Needs: The contracting officer is a key decisionmaker in the acquisition process who requires a multitude of information resources. While every functional community within DoD cannot demand a tailored information system, a cogent case can be made for making the contracting function a major exception. It is this function where significant control is possible over the expenditure of Government funds and where a public demoonstration of integrity, efficiency and managerial effectiveness is of paramount importance. Unfortunately, the full range of contracting office functions and responsibilities are not often articulated by system designers. It is therefore important that procurement information systems not only center on the contracting function, but that contracting professionals be involved in their design.

System Proliferation: The emergence of microcomputer technology has introduced the problem of proliferation into what was once a very centrally managed arena controlled by data processing professionals. Now that user activities can independently acquire low cost, powerful systems to meet local needs, the inherent benefits of centralized control and system standardization are being overlooked. While stand-alone applications such as contract document drafting may not warrant much concern for system standardization, the advanced network applications can be optimized only through compatible linkups. Concepts such as system portability, connectivity, and interoperability take on an added dimension of importance in the environment of decentralized networks. It is important that these cooncepts be translated into adequate technical requirements in future system development efforts.

Excessive Standardization: Too often, system standardization and centralized control procedures are forced onto a function which, by its nature, must remain flexible. Thus potential productivity gains are negated by cumbersome procedures. An optimum procurement automation system would consist of a workstation on the desktop of a contracting officer which, in addition to its capabilities, is fast, responsive, and user friendly. Few contract specialists have the time to spend reviewing a batch downloading of raw data from a remote mainframe site, or inputting milestone data for management reporting purposes. The more procedural steps, computer commands, keystrokes, and disk access time associated with a given system, the less likely it will be considered responsive to the managerial user. Thus, "user ergonomics" with respect to the contracting professional is a concept worth defining in future system designs.

Program Cost & Grandiosity: Cost is always a concern in DoD acquisition programs -- especially in the current period of shrinking resources. Unfortunately, large scale automation programs are experiencing a level of cost growth which is reminiscent of the publicized defense overruns of the 1970s. The General Accounting Office has recently criticized a number of DoD automation programs for poor cost control.[7] Congressional funding cutbacks currently threaten a number of these programs.[8] A major problem is the lack of in-house Government expertise on state-of-the-art technologies. Too often ambitious vendor designs and grandiose proposals are relied upon without an adequate validation of risks. However, by emphasizing proven technologies, smaller systems and decentralized design approaches, the potential for cost growth can be minimized.

Management Coordination: Increased management communication and coordination is becoming essential as automation technology moves into the arenas of interactive networks. However, it is obvious in reviewing the systems evaluated in the recent Logistics Management Institute Report that little coordination has occurred among the Services and component offices on the best approaches and concepts to develop for procurement automation. Too often, a system evolves from a command initiative to solve a local problem, a vendor is tasked to address the problem, and very little effort is made to discover if similar situations have occurred elsewhere. This is unfortunate because a significant number of lessons have been learned and program managers are usually willing to candidly relate their experiences. Procurement problems are very much similar throughout DoD activities but, until recently, forums to discuss automation applications have been nonexistent.

## POSITIVE TRENDS

Given the pace of advancement in automation technology, and the amount of change which has taken place in defense acquisition, it is encouraging to see a recent coalescing of efforts and interests in procurement automation. In 1988, the Deputy Secretary of Defense issued a policy memorandum requiring the use of American National Standards Institute (ANSI) Standard X.12 for all electronic data interchange (EDI) applications in DoD. Standard X.12 is the focus of a formal ANSI Committee to develop uniform standards for inter-industry electronic interchange of business transactions. Its full implementation within DoD will significantly further the development of common EDI procedures for data exchange among contracting offices and industry.

The DoD has embarked on a long range program known as CALS -- Computer-Aided Acquisition and Logistics Support -- with the objective of automating the data support requirements for all phases of the weapon systems acquisition process. CALS is not a single program, but a collection of technical requirements which will provide for all weapon system support data to be contained in electronic media by 1990. [9] The initial technical hurdle, the establishment of digital interchange standards for transmitting engineering drawings and technical manuals was completed in 1988.

Another recent DoD action has been the development of a Defense Interdepartmental Procurement Automation Council (DIPAC) within the Office of the Secretary of Defense. DIPAC will serve as an advisory panel to the Deputy Assistant Secretary of Defense (Procurement) on policy matters relating to procurement automation systems. The Council will also serve as a means of promoting procurement automation concepts, techniques, and procedures among the DoD components.

At the Federal level, the Office of Federal Procurement Policy is sponsoring an interagency task force to support a project on procurement automation for the President's Council on Management Improvement. The task force will address the requirements necessary for Government-wide Acquisition Automation Program, to include an Acquisition Telecommunications Network, ANSI X12 Standards, EDI, Common Databases, Generic Program Libraries.

The surprising attendance level at the 1989 Electronic Contracting Conference, sponsored by the National Contract Management Association, is a good indicator of the accelerating pace of interest in procurement automation systems. Not only were system vendors and technical interests well represented, but specialized procurement policy issues, such as contract auditing and electronic signature transmission were addressed by a wide range of procurement specialists and officials. Such specialized conferences, in addition to the many annual computer industry exhibitions, serve as excellent forums on issues and state-of-the-art applications for procurement automation systems.

## CONCLUSION

The concepts of automated procurement information systems have recently begun to gain recognition for their significant potential to improve the overall defense acquisition process. This evolution has taken place amidst rapidly advancing technology and the growing burden of regulatory requirements on the contracting officer. While advanced office automation systems continue to offer prospects for improving the contract drafting and document assembly process, it is in the area of electronic data interchange and telecommunication networks where the most significant productivity potentials exist. The importance of focusing these system applications on the needs of the contracting officer cannot be emphasized enough. While a number of automation systems exist, or are being developed, for DoD procurement functions, they have typically emerged in an ad hoc fashion with very little coordination among components. The most successful systems are those which are responsive to the contracting officer as the end user, have a decentralized orientation, and achieve a proper balance between standardization and flexibility for tailored functions. Smaller systems, using off-the-shelf technology, will invariably have affordability advantages over large integrated systems using advanced technologies. DoD has taken recent actions to formally establish procurement automation agendas at the interdepartmental level. Aggressive action at this level will be essential in bringing about the significant improvements in productivity offered by emerging technologies and system concepts.

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# ELECTRONIC DATA INTERCHANGE

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## ABSTRACT

In an effort to increase efficiency, decrease procurement time, and improve the acquisition process, tools to implement electronic contracting are being investigated and implemented by Government agencies. These tools range from common workplace systems, such as computerized word processing, to sophisticated expert systems to facilitate decision processes, and the development of American National Standards Institute (ANSI) document format standards for the electronic transfer of data.

Electronic data interchange (EDI) presents many questions that span from legal and regulatory requirements as defined in federal acquisition regulations and public law to audit and control validation, security of documentation in terms of both authenticity and protection of information, and reliability of data. Issues such as Government and contractor responsibility for the transmission of data, misuse of information or tools, and mandates to use EDI by agencies still need resolution. This paper will address each of the areas outlined above, and identify problems and possible solutions. Specifically, the regulatory aspects of EDI in the acquisition process will first be reviewed and potential problems discussed. This will be followed by a discussion of the technology applicable to EDI used in this context and any technology impacts will be highlighted. Finally the paper will conclude with the results and recommendations of the study.

EDI appears to hold promises for benefits to the Government of speed, reduced costs, and paperwork reduction. Even though many companies and Government agencies are using EDI in portions of the acquisition process, EDI is not legally binding in this application. To assure full legal and Federal Acquisition Regulation (FAR) protection, paper backup is necessary. Therefore, the author concludes that before major use of EDI in acquisition can be achieved, the FAR and other rulings have to be changed to reflect the use of EDI. Additionally, technological requirements for the transfer of information must be defined more rigorously than in the current standards to reduce Government risks.

## Introduction

In an effort to reduce costs and to shorten and modernize the procurement cycle many Government agencies are encouraging or, like the Department of Defense (DoD), mandating the use of automated tools and processes for the preparation, transfer, and delivery of procurement information. These tools and processes include basic automation efforts such as the replacement of typewriter-generated documents with word-processing systems to permit easy editing and reformatting of documents, as well as more sophisticated processes such as relational databases and expert systems that guide the user through specific activities such as purchase order processing or requests for proposals. Although many types of electronic data processes are being developed or implemented today, both in the commercial as well as the federal market, there are technical and legal issues that put these endeavors at risk. This paper addresses these issues as they relate to the use of electronic data interchange (EDI) in the federal acquisition process.

EDI, in the context of this paper, refers to the transfer of data between bidders and the Government. Although transfer of procurement data within the Government may have similar constraints as Bidder-Government data, it is not addressed in this paper. The EDI issues and risks being evaluated are limited to those acquisition documents that are specifically referenced in the Federal Acquisition Regulation (FAR). This includes documents providing voluntary information, such as responses to requests for information, and documents containing contractually binding data such as purchase orders and proposal responses.

Figure 1 presents a comparison of hardcopy transmittal of data vs electronic transfer of the same data. In the EDI example, A is the interface between the bidder user and the EDI document transmittal system. This is analagous to the post office in the non-EDI example. B is the EDI transmittal system, consisting of an EDI interface that formats the transmission into a Government specified protocol to transmit the data. In the non-EDI example, B is analagous to the U.S. Postal mail delivery system. C is the interface between the EDI document transmittal system and the Government user, in procurement applications, the bid opening officer or the contracting officer (CO). C is analagous to the current method of accepting hard copy procurement sensitive documentation at the user level.

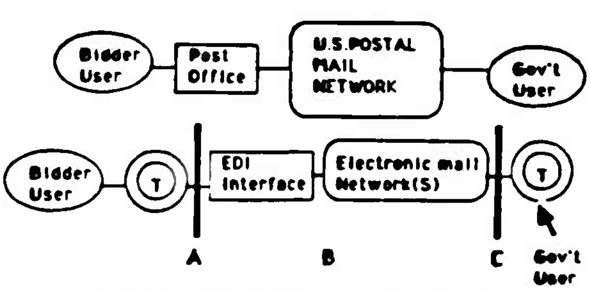


Figure 1 EDI Bidder-Government Interface

## Methodology

The methodology employed in assessing the legal and technical issues in the use of EDI for transmittal of acquisition, procurement, and contractual data was as follows:

- The scope of documents referenced by the FAR and potentially subject to EDI was established
- A review of the FAR and public law was conducted to identify legal constraints placed on specific documents
- Developmental EDI projects and initiatives were reviewed to assess approaches to FAR and public law constraints
- The available technology was evaluated to identify how well it addressed the FAR constraints
- An assessment, and where possible, recommendations were provided regarding both the legal and technical implementation of EDI.

## FAR Referenced Documents

A review of FAR-mandated acquisition procedures that require communication between bidders (Contractors) and the Government, resulted in the following list of applicable documents:

A. Request for Information (RFI) - Government Issued

B. Response to RFI - Bidder Issued

C. Request for Quotes (RFQ) - Government Issued

D. Request for Proposals (RFP) - Government Issued

E. Questions from offerors - Bidder Issued

F. Response to Questions - Government Issued

G. Proposals - Bidder Issued

H. Clarification Requests - Government Issued

I. Response to Clarifications - Bidder Issued

J. Amendments to the RFP - Government issued

K. Requests for Best and Final Offers (BAFO) - Government issued

L. BAFOs - Bidder Issued

M. Purchase Orders (PO) - Government Issued

N. PO Responses - Bidder Issued

## FAR and Public Law Constraints

The FAR sets forth various requirements for the transmission of documents between bidders and the Government. These requirements can be categorized as follows; public access to information, telegraphic transmissions, validation of bid submissions, integrity and confidentiality of data, and requirements for hard copy documentation. These categories of requirements are discussed in the following subsections.

Public access to information - According to the FAR, documents A through F and J can be made generally available to the public, and require no specific security treatment. Items F and J may require some guarantee of accuracy or acknowledgement of receipts if tranferred to a bidder electronically, since they are the basis for bid responses, but this is not addressed in the FAR. FAR paragraph 30.043, Methods for soliciting bids, does not reference any specific solicitation methodology, nor does paragraph 30.044, Records of invitation for bid (IFB), recommend specific recording methodologies. FAR paragraph 30.045.05, Release of solicitation mailing list, clearly states that solicitation mailing lists must be available to the public. Requests for proposals (RFP), unless classified, are also readily available to the public. The Navy Publishing and Printing Service (NPPS) plans to offer an electronic printing service for Navy generated RFPs in the future. The RFP will be issued to bidders on a voluntary basis at the bidders cost. The General Services Administration (GSA) will be using an on-line bulletin board for posting 1989-1990 schedules for microcomputer software and hardware. The issuance, receipt, and treatment of the remainder of these documents, F through I and K through M, are regulated through FAR or public law.

Telegraphic transmissions - The FAR, first issued in 1984, and updated constantly, does not address the electronic transfer of data except for telegraphic transmissions for response to IFB or Purchase orders. Telegraphic transmissions, consisting of telephone calls from the telegraph office followed by hard copy verification of messages, is permitted in specific situations. FAR paragraph 30.042.02, Telegraphic bids, permits this transmission method when pre-authorized as part of the IFB bidder instructions, usually to accomodate short bid times or fluctuating prices. FAR paragraphs 30.053, Bid submission, and 30.054, , Modification or withdrawal of bids, advise of conditions of telegraphic bids but state that for a telegraphic submitted low bid to be accepted, its hard copy version must be received by the Contracting Officer (CO) within five days of bid opening. The only other references to the use of electronic media in the FAR is contained in paragraphs 30.028, Obtaining contractor acceptance and modifying purchase orders, and 30.031, Purchase orders via written telecommunications, of Part 13, Small purchase and other simplified purchase procedures. These paragraphs can be interpreted to mean that telegraphic submissions of purchase orders are accepted when mutually agreeable by bidder and Government. These paragraphs are significant since they waive the requirement for CO (and though, not stated specifically, bidder) signatures.

Validation of bid submissions - Actual requirements for receipt of bids are discussed in FAR paragraph 30.055, Late bids, and 30.058, Opening of bids. These sections reference the acceptable method for validating bid submission dates based on registered or certified U.S. Mail. They also instruct the Bid Opening officer on the requirements to date and time stamp bids on receipt. The date and time stamp and bid opening process may be delegated but it is fully the responsibility of the bid opening officer.

Integrity and Confidentiality - There are many sections of the FAR that address integrity of data, confidentiality, and the general treatment of proprietary bid information. It is assumed that bids transmitted through the U.S. Mail process are not tampered with and remain intact until bid opening.

Requirements for hard copy documentation - Electronic transmission of contractually binding or proprietary information, although utilized frequently, is not legally binding. All laws and statutes currently in force deal with hard copy documentation. For example, Common Law, and the Statutes of Fraud and other sections of the Uniform Commercial Code deal with signatures and contracting authority, and the mailbox rule addresses acceptance and revocation of contracts in relation to time. These rules enhance the stability and security of the paper bound contracting process.

## Developmental EDI Projects and Initiatives

EDI is being implemented today both commercially and within the Federal Government using a range of technologies. These technologies include systems using private and/or public access to company networks and the use of value added networks (VANs) to tranmit data. Some examples of these applications are described below.

The IRS allows commercial income tax agents to electronically submit customers' tax forms to the IRS' Series 1, an IBM microcomputer system, which verifies and acknowledges messages. Passwords are used to identify agents, however, the IRS requires customers of the electronic system to file signatures annually and to provide hard copy backup of tax forms.

The U.S. Customs Service has implemented the Automated Commercial System (ACS) to facilitate the import of foreign goods. Each user accesses the ACS through a unique dial-up number, two passwords, and an individual certification number inserted into a data block in the message header for authentication. Check summing is used to verify integrity of data and acknowledgements of receipt is provided to users.

The Defense Supply Center (DGSC) is using McDonnell Douglas' EDI network for the transmission of POs to the Du Pont Corp. McDonnell Douglas system translated the Government generated POs to ANSI X.12 PO format and transmits them to the Du Pont EDI network. From there, Du Pont takes the responsibility of logging and validating the PO.

There are many other applications of EDI currently being piloted or implemented. These applications provide a wide range of services from the Security Exchange Commissions' transfer of securities data, to an AT & T-Texas Instrument pilot billing program.

Commercial and Government endeavors using EDI do so under specific conditions. These conditions usually fall into three categories, the trusted and proven partnership or trading agreement, limited EDI contracting (10-15% of total) to minimize risks, or pre-transmission agreements outlining the conditions and terms of the EDI transmittals. The major concern of all these system implementors is the legal issues surrounding authentication of sender. None of these scenarios provides legal protection in the case of deliberate fradulent behavior or loss of data integrity. The use of EDI for Federal contracting may have more serious risks since it could involve compromise of the competitive process or of proprietary vendor data that could have significant impact on the profits of a company.

Technical Review

To adequately assess Government risks, EDI technology was reviewed and the methodology for implementing contractual regulations within this technology was evaluated. For conformity of Government terminology, the FAR requirements were restated in accordance with the Government security requirements defined in the Government Open System Interface Protocol (GOSIP) currently mandated for all new automated data processing systems being procured. These requirements are stated below:

1. Authentication or verification of the sender of documents, usually performed through the validation of signatures.

2. Non-repudiation or unforgeable proof that a message was sent, received, or both, usually performed through the document receipt audit process and U.S. Postal certification or registration.

3. Confidentiality or the protection against unauthorized disclosure of data, assumed to be performed through the trusted employee relationship of both the Government and bidder, and the integrity of the U.S. Postal System.

4. Integrity or protection against unauthorized data alteration and manipulation, assumed to be performed through the integrity of the Postal System and trusted employee relationships.

5. Access Control or limiting access to information, currently performed through the use of physical security measures, such as locks, sign-in procedures, etc.

Table 1 identifies the bidder-Government procurement documents referenced in the FAR and their requirements for these five security features.

| Document | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| A. RFI | - | - | - | - | - |
| B. Response to RFI | - | - | - | - | - |
| C. RFQ | - | - | - | - | - |
| D. RFPs | - | - | - | - | - |
| E. Questions | - | - | - | - | - |
| F. Responses | - | • | - | • | - |
| G. Proposals | • | • | • | • | • |
| H. Clarification req | • | • | • | • | • |
| I. Response to Clarfications | • | • | • | • | • |
| J. Ammendments to RFP | - | • | - | • | - |
| K. Request for BAFO | • | • | • | • | • |
| L. BAFO | • | • | • | • | • |
| M. PO | - | - | - | - | - |
| N. PO Responses | - | • | - | • | - |

KEY
1-AUTHENTICITY
2-NON-REPUDIATION
3-CONFIDENTIALITY
4-INTEGRITY
5-ACCESS CONTROL

• REQUIRED
- NON-APPLICABLE

**Table 1 - Documents and Security Features**

Technological Implementation of EDI

EDI technology, regardless of the application, is composed of the following electronic components that are functionally similar to the U.S. Mail system:

- User Agent (UA) - Users access UAs for message processing or delivery. The UA can be either an intelligent device directly connected to the user or can interface to the user via an Input/Output device. The UA formats the message into two parts; an envelope whose protocol is compatible with the data transmission network, and a message with the proper format and protocol to permit conversion to a usable document at the recipients UA. The envelope may contain special directions for routing (directory services), non-repudiation (proof of delivery), integrity (error detection), confidentiality (encryption), and authentication (verifying identification of both sender and recipient). At the receiving end, the UA converts the message to its original state for transfer to the end user. The user access UA is analagous to the creation and submission of a letter to the U.S. post office, while the receiving UA is analagous to delivery of the letter by the post office to a user's home or office.

- The Message Transfer System (MTS) - The MTS may be a leased or dial-up line or data network(s), which is responsible for implementing the directions contained in the message envelope. These include the responsibility for routing, storing, delivering and verifying the delivery of messages to the recipient UA. The MTS is responsible for transmitting special handling information from one network node or network to another. The MTS is analagous to the U.S. Postal mail network delivery service, which might include a variety of transmission media such as plane, truck, and manual processing aimed at delivering a letter to its final post office destination.
- The Message Store (MS) - The MS is an optional feature that permits messages to be held until the recipient is available or to be filed until a user pre-determined delivery date is reached. The MS is analagous to a Post Office Box.

The specific network design of these components are determined by the application and the organization's guidelines and standards.

Network design for Federally Regulated Procurement Document Transmission

The EDI applications addressed in this paper are relatively short-term and the partners change from one procurement to another. Although most Government agencies transfer internal documents electronically today, these networks are for internal use and would most likely not be suited for the transfer of documents from non-network compatible computers or procurement sensitive data that requires confidentiality in the treatment of both hard copy and electronic data. For these reasons, it is anticipated that an electronic mail (E-Mail) system or systems would be used to transmit these documents. E-Mail may be provided through a mixture of Government, private, and commercially available VANs. GOSIP mandates that the Government implement the OSI X.400 message handling standards that define a specific set of interfaces for internetworking computers for E-mail applications.

The X.400 security features, authenticity, non-repudiation, confidentiality, integrity, and access control, needed to safeguard procurement sensitive electronic data, are defined in the X.400 documentation, but detailed implementation of the features is vendor specific. Figure 2 presents an overview of a network that might be used for EDI. Each of the letters in the figure represent an interface where security is required. Each of the numbered areas represents one of the five security feature that must be implemented to meet FAR requirements.

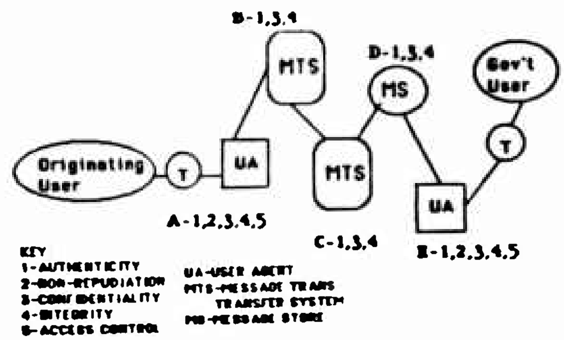


FIGURE 2 -SECURITY REQUIREMENTS FOR NETWORK INTERFACES

The following sections discuss each of the security features as they are implemented today and identify risks associated with them.

Authentication - Procurement related documents requiring authenticity call for written signatures. For most computer transactions, user authentication is limited to access codes, passwords, or personal identification numbers (PINS), which are easily compromised and are not contractually binding (or are liability limited) on the user. One of the approaches recommended for authentication is the use of public/private key technology. Software applications using RSA algorithms, an approved X.400 standard, use pairs of reciprocal keys for encryption and decryption and electronic signature authentication. The keys are generated through the software program itself, and public keys can be kept in a readily accessible file. One of the major disadvantages of public/private key systems is the costs and administrative overhead involved in the distribution of keys. In this application the software manufacturer becomes the key manager. Administration of a public key directory would probably be the responsibility of the Government. The U.S. Bureau of Labor Statistics is currently using this technology to authenticate signatures to validate network software changes. The Internet, the computer network that ties together over 400 Government and commercial computer systems, will be using this technology to encrypt and certify users of the Internet. Another technology that warrants further investigation as a possible means of authenticating electronic signatures is the introducing of handwritten signatures transmitted as part of documents through the use of electronic stylus. If this technology, currently available in specific software applications, can be transmitted through non-vendor specific networks, it may serve the same function as a handwritten signature. As noted in Figure 2, authentication must be verified at each interface or a trusted third party must be able to verify authenticity of documents.

Non-Repudiation - Currently all electronic mail systems have the ability to time stamp documents. Unfortunately, these time stamps are not uniformly implemented. Time stamping may be generated at the submission, storage, or receipt of a message. Additionally, to provide unforgeable proof that a document was sent requires the services of a trusted third party. For procurement documents that must be received prior to a certain time, storage in an electronic mail box may not be satisfactory. In this case, the trusted third party might be required to hold copies of the encrypted document until delivery time. Similar to late receipt requirements for bids in the FAR, the Government might mandate that time stamping be performed at a specific point, such as the SM or UA, prior to bid closing time. This mandate would also apply to acceptance or modifications of POs or other time related data.

Confidentiality - Confidentiality rules for end users should follow the same criteria used today, with agencies preparing guidelines for the handling of electronic generated procurement sensitive data. This data, when released on a public or private network, should be protected. Encryption techniques add network overhead and are also costly. Encryption can be performed at the point of origin and receipt, or can be performed at the UA. If authentication devices also permit encryption, these might be appropriate tools to look at for this function. Electronic data will probably pass through several networks, many of which might provide intelligent processing. For this reason, audit trails of routing and transaction flows may be required in cases where breaches in confidentiality are suspected. The E-Mail system used must record and transmit the message distribution list to all recipients. Also blind copies and forwarding of messages must be disallowed.

Integrity of Data - Today it is assumed that hard copy documents transmitted through the U.S. Post Office are not altered in the process. As electonic data flows through various networks, validation of the integrity of data may be a major requirement for EDI implementation. Many agencies and commercial organizations are in the process of working with the American National Standards Institute's (ANSI) X.12 committee, which defines EDI messages by a standard formatting syntax called EDIFACT. The Freedom of Information Act and many sections of public law limit the Governments ability to restrict data to certain media or formats or to limit the publics access to software on-line data. In addition, intelligent systems processing EDIFACT data may alter the data inadvertently through processing. Translations from different media and formats, such as facsimile to E-Mail may also jeopardize data integrity. Error detection techniques should be used, whenever possible. In addition, a trusted third party will probably be required to validate integrity.

Access Control - Access control for EDI should be guided by the same criteria that is used for hard copy documentation and standard procedures for computer data security.

Summary and Conclusions

The Government procurement process is under criticism for abuse and mismanagement. EDI is seen as a way to increase productivity and effectiveness and to reduce costs. Many Agencies have already developed EDI systems for purchase and payment for equipment. These programs may be at risk because they violate current Federal and common law. In some cases the technology used has not been carefully mapped to FAR constraints and a technological implementation plan that minimizes the risks associated with these constraints has not been developed.

To minimize risks to a Federally supported EDI program, it is suggested that the Government take a two-pronged approach to implementing EDI; a managerial approach that develops and influences regulatory change, and a technical approach that validates technological ability to address regulatory constraints.

On a managerial level, Agencies might develop and participate in inter-agencies committees and communicate with groups such as the Office and Management and Budgets task force on EDI and American Bar Association's Electronic Messaging Task Force, to formulate an EDI policy. The aim of this policy would be to devlop reasonable alternatives to modify laws or create new laws for electronic data.

At the technical level, consortiums composed of various factions of the Government and industry could review and assess the available technology and its risks in relation to the regulatory constraints of EDI. This consortium would emphasize the needs for the development of more rigorous standards for EDI. These standards would quantitatively and qualitatively describe feature implementation that would assure uniformity and true transparency between networks. The Government could develop a functional specification for EDI transmission services that would lead to a competitive procurement or, for more open competition, a certification of vendors who provide acceptable EDI transmission services. An internal review of Agency and Government-wide procurement process could be conducted to standardize procedures, forms, and tasking components within and between agencies. Wherever possible a consolidation of functions and task, especially of redundant, rote tasks, should be performed. In addition, the consortium could look for a suitable Government agency or private, non-Government-competitive business (businesses) that would qualify to act as a trusted third part to administer and oversee EDI security.

Finally, the finding of this technical consortium should be used to provide verification of available products and planning to support legal changes.

EDI is being implemented. As telegraphic bids and POs have proven in the past, EDI can help to shorten some procurement cycles and reduce costs. The scope of the use of EDI, especially for regulated documents, needs further study. A joint effort between Government and industry, that is supported at a managerial level, may help to facilitate the use of EDI.

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# MAKING PAPERLESS CONTRACTING A REALITY

**Dr. Diane R. Murphy, Procurement Automation Institute**


## ABSTRACT

Automation is playing a greater part in the acquisition process, as the benefits of information technology in the paper-intensive procurement process are realized. The end-point of those automation initiatives is seen as the paperless contracting process where data is interchanged between requiring office, purchasing organization, vendor, and payment office without the need for paper and signatures.

Paperless contracting is not yet a reality, however, there are several emerging technologies which will facilitate its ultimate implementation--workstations, imaging techniques, electronic data interchange (EDI) to name a few.

This paper discusses the concepts of paperless contracting, the state of the art in emerging technologies, and the issues which will impede the introduction of the paperless contracting environment.


## INTRODUCTION

The concept of "paperless contracting" is extremely attractive since it promises improved productivity, high-levels of accuracy, and enhanced capabilities for management review and control.

What is "paperless contracting"? It is commonly used to reference the use of information technology (electronic processes and media) to collect, process, and store procurement data from its inception in the acquisition process (at the requiring office) through the entire procurement cycle (including interfaces with vendors for ordering, fulfillment, and invoicing operations).

The main advantage of paperless contracting is its focus on bringing information, not paper, to the buyer.

Paperless contracting is now possible, because of emerging technologies such as Electronic Workstations, Image Processing, Advanced Text Retrieval, Electronic Data Interchange (EDI), and teleconferencing.

**However, paperless contracting is not yet a reality.** Considerable research and development activities are necessary to ensure the advantages of paperless contracting are available to a wide range of procurement environments in a timely manner.

## TYPICAL USE OF INFORMATION TECHNOLOGY IN THE ACQUISITION ENVIRONMENT

Recent studies (Reference 1) have shown the increased use of automation within the acquisition community. However, most major automation programs such as the Army's SAACONS system are "closed" systems, i.e., they focus on automation within the procurement environment only with manual interfaces with the requiring offices and paper interfaces with vendors.

Another characteristic of the current automation initiatives is their use of conventional on-line ADP technologies. Users typically access the systems through a terminal; data is entered and retrieved from databases; and the major outputs are either displays on the terminal or output reports. While these systems offer substantial advantages in making information readily available to buyers, they also have a negative impact on productivity with large data input requirements within the acquisition office.

## OTHER ADVANCED AUTOMATION INITIATIVES

Throughout the acquisition community, there are, however, several instances where some forward-thinking individuals are experimenting with aspects of paperless contracting. Examples of these projects include:

- Electronic submission of purchase requests from requiring offices.
- Use of workstations to review and analyze contract administration data previously handled through hardcopy reports.
- Use of electronic data interchange (EDI) to process purchase orders and subsequent invoices with vendors.
- Electronic archival storage of contract files utilizing optical disk technology.

Many of the advances in this area were discussed in the National Contract Management Association (NCMA), Electronic Contracting Workshop held in Philadelphia, April, 1989 (Reference 2).

## WHAT ARE EMERGING TECHNOLOGIES

Emerging technologies include capabilities such as:

- Workstations.
- Optical Storage Media.
- Image Scanners.
- Optical Character Readers.
- Electronic Data Interchange (EDI).
- Integrated Systems.

These technologies, together with conventional ADP technology, make the concept of paperless contracting a possibility.

### Workstations

Users are seeing a progression on their desk. Using a terminal, many users were (and some still are), linked to a mainframe or minicomputer under the control of another organization (using MIS). Many users have become frustrated because of computer down-time (usually at times of crisis) and because of rigidity (slowness to change system to meet evolving requirements). Many users recognized the advantages of microcomputers, and individual PC's became common-place on a buyer's desk. Capabilities such as LOTUS 1-2-3 opened up opportunities for buyers to analyze data for contracts for which they were responsible. However, for most, it led to personal databases and a lack of potential for data sharing for the procurement organization as a whole, leading to reductions in management controls.

Today's technology, the workstation, provides the buyer with the potential to take advantage of both of these circumstances. Workstations use windowing software to facilitate multi-application access on the same machine. Workstations generally provide stand-alone processing together with access to other systems (local-area networks , file servers, mainframes, etc.).

### Optical Storage Media

Today's database are largely stored on magnetic disks with backup and archival information stored on magnetic tape. Optical storage provides capabilities for long-term archival storage and backup with some capabilities for information manipulation. Progress in this area has been hampered by the availability of read-only media (pre-recorded, CD and CD-ROM). However, recently, several products have become available which utilize WORM techniques (write once, read many times). These technologies have obvious advantages for such applications as contracting files since:

- Data may be written locally.
- They provide an unerasable "audit trail".
- High capacities (200/300 megabyte per cartridge) may be stored either as "standalone disks" or as platters in "juke-boxes".

### Image Scanners

Image scanners allow the input of text or graphics for storage and retrieval as images: however, the user is not able to retrieve data within the image.

There are several competing image scanners with major differences in:

- Document Size.
- Maximum Throughput.
- Resolution, Scalability.
- Compression/Decompression.
- Hardware Interfaces.

Quality, once the major problem with image scanning has largely been resolved by new scanning techniques.

### Optical Character Readers

Optical character readers prepare text for search and retrieval operations where access is required for all or part of the text. There are several competing products, differing mainly in the quality of conversion and the speed of operation.

Implementation of optical character technology has been impaired by the high reject rates associated with the earlier technology. However, recent technology has greatly improved quality, although a manual review is still necessary.

Information read using optical character readers can be programmed for later data manipulation, and provides the procurement community with mechanisms for entering data in a cost-effective manner.

### Electronic Data Interchange (EDI)

Electronic Data Interchange (EDI) provides a formal structure for the electronic interchange of data between procuring organizations, and vendors. The ANSI X.12 standards provide the framework for commonality among differing communications and information systems. However, there appears to be developing a multitude of customized interpretations of the standards which will result in limitations to a generalized procurement environment utilizing EDI.

### Examples of Integrated Systems Technology

Acquisition communities wishing to take advantage of these emerging technologies are forced with three alternatives:

- Obtaining in-house expertise in each of the various emerging technologies.
- Using a systems integration organization to bring together the various technologies in a single unified system.
- Procuring a single-vendor integrated solution.

Examples of single-vendor integrated solutions include:

- Wang Integrated Imaging System (WIIS).

Wang has developed a total hardware/software solution which integrates text, image, and voice information. The user may invoke multiple windows for each area and can transfer all information via electronic mail.

- BBN State Document Communications System (SLATE).

BBN has developed an integrated software solution (for UNIX workstations) which combines text, images, spreadsheets, and voice in a single window. Information can again be transferred by electronic mail and users can interact with each other using multimedia teleconferencing.

## ISSUES WITH PAPERLESS CONTRACTING

Developing a total paperless contracting environment is an enormous undertaking. Procurement offices are recommended to start small, and to select specific paper-intensive operations for an initial automation initiative. Initial attempts are likely to be less than successful and must be considered.

The key to future enhancement will be standards enforcement. Because of the many technologies involved, it is necessary to ensure that all products conform to these standards to minimize interface problems.

The organizations must acquire systems integration expertise--the solutions require a complex interaction of hardware and software.

A common theme impacting paperless processes is replacement of the manual signature on a piece of paper. There is considerable technical effort being expended in this area, but legal acceptance will remain a stumbling block.

Another important issue which has arisen, particularly with the use of EDI, is the one of competitiveness. How many requirements can the government place on business (small or large) for the hardware/software to facilitate electronic interfaces?

## CONCLUSIONS/SUMMARY

There are few research and development efforts which are aimed at the systematic evaluation of information technology within the acquisition community. Instead, far-sighted operational purchasing organizations must bear the cost of experimentation and the potential negative impact on the day-to-day functioning of the procurement operations. To capitalize on this investment by a few, it is essential that professional organizations such as the National Contracts Management Association (NCMA) provide forums such as the Electronic Contracting Workshop to facilitate the sharing of experiences.

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# "THE PAPERLESS PROCUREMENT SYSTEM"

## (TPPS)



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U. S. DEPARTMENT OF EDUCATION

## A B S T R A C T

TPPS was developed using "Knowledgeman" (KMAN) an integrated software program produced by Micro Data Base Systems of Lafayette, Indiana.

"KMAN" as it is more commonly referred to combines data base management, spread sheet, graphics, word processing, communications, forms design, natural language programming and utilizes SQL retrieval concepts. All of this and more is included in one program.

The TPPS essentially gives the procurement professional the ability to put the entire contract file into a computer. At the heart of the system which is menu driven throughout are the major contract forms which are used by contracting offices dealing in Federal procurement. This includes the following Standard Forms (SF):

- o SF 33 Solicitation, Offer, Award
- o SF 30 Amendment/Modification
- o SF 26 Award
- o SF 18 Request for Quotations

The Department of Defense Forms:

- o DD 1155 Purchase Order
- o DD 1547 Weighted Guidelines
- o DD 1610 Travel Order

Optional Forms:

- o OF 60 Contract Pricing Proposal
- o OF 347 Purchase Order

Also included are Requisition Forms and Receiving Reports.

**More recently Department of Agriculture procurement forms and the entire Federal Acquisition Regulation (FAR) and a key word retrieval program have been added.**

The system has been installed and is in use or being tested by more than 25 procurement offices throughout the U. S. It is fully transportable across the Government and could be implemented by Small Businesses for less than $2,000 including hardware with a 40 megabyte hard disk capacity.

## BACKGROUND DISCUSSION

Since 1981, I have been using a micro-computer and for years there has been discussion of a "paperless office." Procurement or acquisition is one of the most labor intensive, paper oriented functional areas in the business world.

I kept hoping that "someone" would develop an electronic system which would run on personal microcomputers and eliminate all of the paper shuffling in procurement. This would allow procurement professionals and others who have to deal with all of this paper to concentrate on the real problems of cost effective acquisition of the goods and services required to run the federal government.

## DISCLAIMER

This article/speech was written/delivered by the author in his private capacity. No official support or endorsement of the U. S. Department of Education is intended or should be inferred.

At that time there were over 15 data base programs and dBase II 1/ was the most publicized. However, it only had the capacity for 32 fields per record and later on "dBAse III" 1/ and even "dBase III" 1/ plus only has 128 data fields per record. Since the average federal government form has approximately 140 fields this was unacceptable. Creating 2 or 3 separate data bases to create one form didn't make any sense.

The desired program also would not require a computer programmer to modify or maintain it. The average secretary or contract specialist does not know Lisp, Prolog, or Ada. If the truth were known, not to many programmers do either.

The search was finally narrowed down to seven (6) programs which were:

| | | |
|---|---|---|
| Condor | dBase II | Lotus 123 |
| MBA | Oracle | KMAN |

"Knowledgeman" was clearly the best choice and the most cost effective.

Note: All of the programs cited above now have later versions, but the choice would still be the same.

The current version of "Knowledgeman has the following limitations:

**DESIGN LIMITS OF THE SYSTEM**

| | |
|---|---|
| Records per table * | ...1,073,741,823 max |
| Characters per record | 65,535 max |
| (Fields per record | 255 max) |
| Characters per field | 65,535 max |
| Numerical accuracy * | 14 digits |
| Command line length (characters) | unlimited |
| Index keys per table | unlimited |
| Fields per index key | 65,535 max |
| Index key length (characters) | 65,535 max |
| Tables simultaneously in use * | 50 max |
| Control break criteria per report | 255 max |
| Elements per screen or report form | unlimited |
| Different foreground colors per screen form | 8 max |
| Different background colors per screen form | 8 max |
| Program length (lines) | unlimited |
| Working variables | unlimited |
| Security code combinations | 65,535 max |
| Rows per spredsheet | 255 max |
| Columns per spreadsheet | 255 max |
| Files open at once * | 50 max |

1/ A Trademark of Ashton Tate

* Numeric accuracy, maximum number of tables, and records per table depend on the memory capacity of the operating system/cpu.

**TEXT**

"The Paperless Procurement System" (TPPS) was developed using "Knowledgeman," a trademark of MDBS, Lafayette, Indiana. The cost of "Knowledgeman" is less than $700 retail on an individual user basis. Lan versions and site licensing agreements for large quantity purchase can reduce this to less than $150 per user. It is therefore, well within the reach of an individual or Small Business as far as being able to purchase it.

With "Knowledgeman" it is possible to create data bases, design forms and reports, develop graphics, use the word processing capability for writing, the spreadsheet for cost and price analysis, and transfer data between these various programs without having to leave the program or change disks on a Hard Disk System. It is essentially a natural-language processor.

The heart of (TPPS) uses the following menu system.

"THE PAPERLESS PROCUREMENT SYSTEM",
COPYRIGHT, 1985, 86, 87, 88, 89

Main Menu

Do you wish to:

1. Create a Purchase Order System using Menu #1
2. Create a Solicitation/Contract System Menu #2
3. Use Disk # 22 the Directory disk.
4. Use the KMAN Demonstration Program.
5. Prepare a DOD Travel Order.
6. Return to KMAN
7. Return to the System

MENU #1 FOR THE "PAPERLESS PROCUREMENT SYSTEM", COPYRIGHT 1985, 86, 87, 88, 89

Do you want to?

1. Prepare a requisition or continuation sheet.
2. Use the finance office data entry disk.

3. Prepare an OP Form 347 civil agency purchase order or continuation sheet.

4. Prepare a Standard Form 18, Request for Quotations or continuation sheet.

5. Prepare a Receiving Report

6. Prepare a DD Form 1155 Purchase\Delivery Order or continuation sheet.

7. Prepare a Department of Agriculture Purchase Order or continuation sheet.

8. Return to Main Menu

9. Return to System

MENU #2 FOR THE "PAPERLESS PROCUREMENT SYSTEM", Copyright 1985, 86, 87, 88, 89

Do you want to?

1. Prepare a Standard Form 33, Solicitation, Offer, Award or continuation.

2. Prepare a SF 30, Amend. of Solicitation/Mod. of Contract or continuation.

3. Prepare a Standard Form 26, Award or Continuation.

4. Prepare an Optional Form 60, Contract Pricing Proposal

5. Prepare a DD Form 1547, Weighted Guidelines Profit/Fee Objective

6. Return to Main Menu

7. Return to System

**WHAT'S THE BIG DEAL IN AUTOMATED FORMS?**

When discussing office automation, many people talk about the goal of a paperless office. Few have done anything about it.

One of the major obstacles is the use of literally hundreds of pre-printed paper forms in the daily office routine. While numerous federal agency-specific automation initiatives are in progress, few, if any, of the software application programs are transportable. They cannot be used throughout the government and in the private sector. Nor are they used by more than one functional division such as financial management, procurement and program requirement offices.

The TPPS eliminates both of these obstacles for federal acquisition management. This modular system is a series of menu-driven application programs for use by procurement people both inside government and in the contractor or vendor companies.

With this system it is possible to prepare, store and retrieve all the documents contained in a contract or purchase order file electronically. The need for hard copy or paper files in a procurement office -- as well as for procurement related documents that are retained in hard copy the requiring, receiving and the finance offices -- is eliminated.

**DOING AWAY WITH FORMS**: It gets rid of the stacks of pre-printed forms by storing the forms on a computer which can print them on plain bond paper if hard copy is required. These hard copies could however be thrown away. It reduces clerical errors because the program does all required arithmetic, and once information is typed on one form it does not have to be retyped on another form.

As an example, the current manual method requires a procurement office to retype much of the information on an agency requisition form (accounting data, item description, quantity required, unit, unit price, total price of the item and total of the requirement) onto a purchase order form. The system eliminated the need for retyping not only these forms but for other forms used in procurement such as the receiving report and Travel Orders.

This turnkey, transportable system can run on practically any microcomputer using PC-DOS or MS-DOS. It will also run on a Digital Equipment Corp. VAX-11 series minicomputer, either a single-user or networked version.

Appendix A provides examples of the forms that are reproduced. If hard copies are required they can be printed on plain paper using either an Epson or Okidata 131-column printer. The system can be adapted for other printers.

**OPTIMAL CONFIGURATION**: For optimum use, each office involved in. he procurement cycle -- the requiring, receiving, financial management, property management offices -- would be using a LAN version of "Knowledgeman" on a microcomputer with at least 640 K RAM, a 30 Megabyte hard disk running at 10 MHz. Larger storage is preferred, but not necessary.

The advantages of this configuration are two fold: If one piece of equipment breaks down, the whole system does not stop and it eliminates the need for transporting floppy disks between offices, However for agencies with a minicomputer installed, this hardware may be the agency's choice. A small business could run the system on a single microcomputer.

**CONVERSION**: There is a conversion program that makes it possible to store the completed requisition or several requisitions.

These requisitions can be stored in a temporary file on a floppy disk. This information can then be transferred to purchase-order data base which may be located in another office without having to retype the data. This is not ideal, but if an office does not have a Local Area Network (LAN) it still beats retyping the data. The same is true for the Standard form Form 18, Optional Form 347, DD Form 1155, etc.
etc.

## REPORTS CAPABILITIES

The system also can convert data from any of the data base to a spreadsheet format or visa versa. What-if determinations can be made with any of the financial information. Macros or procedure files can be used to extract any data from he various forms for report purposes.

For example, one procedure file will extract all of the purchase orders award to women-owned business, including individual-order dollar amount of the awards and minimum and maximum dollar amount of individual awards. This information is obtained by simply typing Perform Women. Another will automatically prepare a bidders mailing list from the orders or solicitations prepared.

All the data entered into these documents can be sorted or indexed in any manner by state, ZIP code, dollar amount, contractor name, requiring office, delivery point, etc. The system can be used by either Department of Defense or civilian agencies because it includes the purchase order form Optional Form 347 for civil agencies and the DD Form 1155 order for DOD. Lately I have also added U. S. Department of Agriculture forms as well as the DOD travel order form DD Form 1610.

## OTHER FUNCTIONAL AREAS

As indicated by the travel order form above, there is no reason that TPPS couldn't be used for Personnel forms and other functional management area forms if "someone" were willing to take the time to do it.

## ADDITIONAL FREE SOFTWARE

Distribution of the public domain software program "Deskmate," 2/ a memory resident program with alarm clock, calendar, calculator, DOS commands, note files, phone dialer and a conversion to use the microcomputer as a typewriter is also provided with TPPS.

During 1987 the complete Federal Acquisition Regulation (FAR) for reference purposes (thanks to the Environmental Protection Agency) was included with the TPPS. This gives the contract specialists reference guidance at their finger tips. Using "Memory Lane" a trademark software program of the Group L Corporation, Herndon, Va. it is also possible to pull any FAR clause or group of clauses out of the FAR and insert them into any of the procurement forms without retyping. Memory Lane retails for $150.

Finally, the Department of Energy's "Contract Writing System" is provided to agencies that are interested. This program will: by answering a series of questions assemble contract clauses into a single file and automatically develop a table of contents for the user. It does not however do forms. Currently, the Department of Energy has this program under revision, but will provide it to government requesters at a later date upon request.

Appendix B provides a list of offices that have participated in this pilot effort.

2/ Copyright, Alternative Decision Software, Inc. Lancaster, NY 14086

## DISKETTES SHIPPED WITH TPPS

- "The Paperless Procurement System" Copyright 1985, 86, 87, 89 (TPPS)
  - Includes 16 Diskettes plus Disk # 23 Menubldr, requires 5 megabytes of memory.
  - There also three (e) additional disks containing the manual and a PC miscellaneous disk with Deskmate a public domain utility program.
- The Contract Writing System (CWS)
  - Includes 10 Diskettes and requires 5 megabytes of memory.

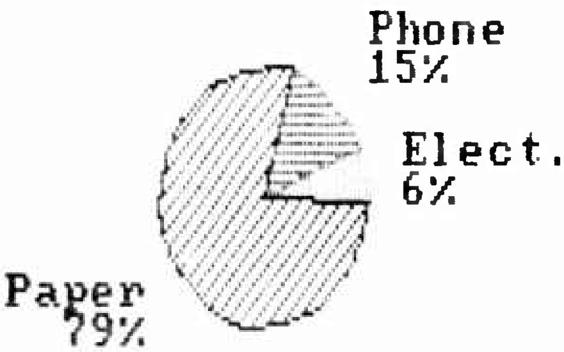
NOTE: The CWS is currently under revision by the Department of Energy. They have forward copies of this program to other federal agencies upon request.

## GRAPHICS

For an idea of the graphics capability of KMAN see Appendix C which shows a free form Map of the U.S.A. and the Shuttle. This type of graphics could of course be incorporated into a statement of work, request for proposal, etc.

## LESSONS LEARNED

Paper still leads electronics in corporate communictions. Only 6% of the business transactions undertaken by Fortune 1000 corporations involve electronics.




This still leaves about 4,000 Federal acquisition offices to become paperless, but it is a start.

As indicated in the pie chart above, paper is still the predominant means of communication, accounting for 79 percent of business communications. Person-to-person or telephone communication accounts for another 15 percent.

This information was obtained in a recent study conducted by EDI Research, Inc., Oak Park, Ill., a joint venture of UAI Technology Inc. and EDI Group Ltd. as shown in The Washington Post December 29,1988.

Electronic communication was broken down into two categories. Free-form electronics are used for 4 percent, while electronic data interchnage (EDI), a specific system of exchanging data electronically, is used by 2 percent of the companies.

Statistics available from the GSA electronic bulletin board MUFFIN show there are federal agencies where the ratio for microcomputers to employees is 1 microcomputer for every 39 employees.

According to the Office of Federal Procurement Policy there are more than 4400 federal procurement or acuisition offices. Yet only 25 of those were willing to try TPPS or CWS and the cost would have been minimal, i.e. the price of copying the floppy diskettes.

Gradually, however things will change.

The Department of Interior has developed a system called B.R.A.I.N. which will run on microcomputers and when they get the micros their procurement professionals should be able to do most of the work they perform electronically.

The Department of the Army installed at 200 installations a system called SAACONS which will run on microcomputers and accomplish the same thing.

Finally, it is my understanding that the system at Hill AFB, Utah can now be run on Zenith Microcomputers.

# APPENDIX A

REQUEST AND AUTHORIZATION FOR TDY TRAVEL OF DOD PERSONNEL

(Reference: Joint Travel Regulations)
Travel Authorized as Indicated in Items 2 through 21

1. DATE OF REQUEST: 12-DEC-86

REQUEST FOR OFFICIAL TRAVEL

| | | | |
|---|---|---|---|
| 2. NAME (Last, First, Middle Initial)<br>WEBB, DAVID A.<br>SSN - - | | 3. POSITION TITLE AND GRADE OR RATING<br>Procurement Analyst | |
| 4. OFFICIAL STATION<br>WASHINGTON, D. C., 20202<br>U. S. DEPARTMENT OF EDUCATION | | 5. ORGANIZATIONAL ELEMENT<br>Office of Management<br>Contracts and Grants Svc. | 6. PHONE NO.<br>(202)-732-2529 |
| 7. TYPE OF ORDERS<br>SINGLE | 8. SECURITY CLEARANCE<br>NONE | 9. PURPOSE OF TDY<br>PROVIDE ASSISTANCE ON LAN KNOWLEDGEMAN PROCUREMENT SOFTWARE PROGRAM | |
| 10a. APPROX NO. OF DAYS OF TDY (Including travel time)<br>THREE (3) | b. PROCEED O/A(Date)<br>17-DEC-86 | | |

11. ITINERARY [X] VARIATION AUTHORIZED NOTES:

| FROM | TO |
|---|---|
| Washington, DC | Lakehurst, NJ |
| | AND RETURN |
| | |
| | |
| | |
| | |

12. MODE OF TRANSPORTATION

| COMMERCIAL | | | | GOVERNMENT | | | PRIVATELY OWNED CONVEYANCE (Check one) |
|---|---|---|---|---|---|---|---|
| RAIL | AIR | BUS | SHIP | AIR | VEHICLE | SHIP | RATE PER MILE: $20.5 |
| | | | | | | | [X] MORE ADVANTAGEOUS TO GOVERNMENT |
| [ ] AS DETERMINED BY APPROPRIATE TRANSPORTATION OFFICER (Overseas Travel Only) | | | | | | | [ ] MILAGE REIMBURSEMENT AND PER DIEM LIMITED TO CONSTRUCTIVE COST OF COMMON CARRIER TRANSPORTATION & RELATED PER DIEM AS DETERMINED IN JTR. TRAVEL TIME LIMITED AS INDICATED IN JTR. |

13. [X] PER DIEM AUTHORIZED IN ACCORDANCE WITH JTR
[ ] OTHER RATE OF PER DIEM (Specify)

14. ESTIMATED COST

| PERDIEM | TRAVEL | OTHER | TOTAL | 15. ADVANCE AUTHORIZED |
|---|---|---|---|---|
| $ 62.00 | $ 82.00 | $ 0.00 | $ 144.00 | $ 136.00 |

16. REMARKS(Use this space for special requirements, leave, superior or 1st-class accommodations, excess baggage, registration fees, etc.)
ALL TRAVELERS WILL LIQUIDATE THEIR ORDERS WITHIN 10 DYS AFTER RETURN
FROM TRAVEL POV AUTHORIZED TO AND FROM AND IN AND AROUND LAKEHURST, NJ
BOQ IS AVAILABLE.
COPY OF ORDERS AND PROCESSED CLAIM MUST BE SENT TO:
K. THEIBAULT
NAVAL AIR ENGINEERING CENTER
CODE 192, BLDG. 129
LAKEHURST, NJ 08733-5036

| 17. REQUESTING OFFICIAL (Title and signature) | 18. APPROVING OFFICIAL (Title and signature) |
|---|---|
| | |

AUTHORIZATION

| 19. ACCTG. CITA-TION | APPROPRIATION AND SUBHEAD | OBJECT CLASS | BUREAU CONTROL NUMBER | SUB-AUTH | AUTHORIZATION ACCOUNTING ACTIVITY | TYPE | TRAVEL ORDER (Tango)NO) | COST CODE |
|---|---|---|---|---|---|---|---|---|
| | 2A17X4912.1958 | 000 | 77777 | 0 | 068335 | 2E | 789861 | 007421900006 |
| | | | | | | | | |

| | |
|---|---|
| 20. ORDER AUTHORIZING OFFICIAL(Title and signature) OR AUTHENTICATION | 21. DATE ISSUED<br>12-DEC-86 |
| | 22. TRAVEL ORDER NUMBER<br>N6833597808O863 789867 |

DD FORM 1610 S/N 0102-LF-016-7702

## APPENDIX A

**AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT** | 1. CONTRACT ID CODE D | PAGE OF PAGES

| | | | |
|---|---|---|---|
| 2. AMENDMENT/MODIFICATION NO. P00002 | 3. EFFECTIVE DATE 85/06/05 | 4. REQUISITION/PURCHASE REQ. NO | 5. PROJECT NO. (If applicable) |

6. ISSUED BY CODE
Department of the Navy
Naval Air Engineering Center
Contracting Division
Bldg. 129 Attn: 1945A
Lakehurst, NJ, 08733-5000

7. ADMINISTERED BY (If other than Item 6) CODE
Donnamarie Dooley
Phone (202) 433-6730
Autovon 288-6733

8. NAME AND ADDRESS OF CONTRACTOR (No., street, country, State and ZIP Code)
Federal Data Corporation
4601 North Park Avenue
Chevy Chase, MD 20815

CODE | FACILITY CODE

X | 9. AMENDMENT OF SOLICITATION NO.
0 |

9B. DATED (SEE ITEM 11)
/ /

1 | 10. MODIFICATION OF CONTRACT/ORDER NO.
N66032-85-D-0008

10B. DATED (SEE ITEM 13)
85/05/01

**11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS**

[0] The above numbered solicitation is amended as set forth in item 14. The hour and date specified for receipt of Offers [0] is extended. [0] is not extended.
Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:
(a) By completing items 8 and 15, and returning copies of the amendment: (b) By acknowledging receipt of this amendment on each copy of the offer submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified

12. ACCOUNTING AND APPROPRIATION DATA (If required)

**13. THIS ITEM APPLIES ONLY TO MODIFICATION OF CONTRACTS/ORDERS, IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.**

| | |
|---|---|
| X 0 | A. THIS CHANGE ORDER ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14. ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A. |
| 0 | B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation data, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103 |
| 0 | C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: |
| 1 | D. OTHER (Specify type of modification and authority) Mutual agreement of both parties |

**E. IMPORTANT:** **Contractor [ ] is not, [X] is required to sign this document and return 1 copies to the issuing office.**

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF action headings, including solicitation/contract subject matter where feasible.)

1. For administrative convenience, because of the size of the solicitation and all seven (7) amendments comprising initial award, Contract No. N66032-85-D-008, Mod P00001 is hereby converteu from a unilateralmodification to a bilateral modification to reflect the complete agreement between the parties that resulted from the award of this contractin response to IFB N66032-85-B-0004.

2. As a result of this modification, the total amount of this contract, and the terms and conditions of this contract remain unchanged.

3. Execution of this modification, does not resolve the issues raised by FDC in its letter of 20 May 1985 which are reserved for subsequent action.

**Except as provided herein, all terms and conditions of the document referenced in item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.**

| | |
|---|---|
| 15A. NAME AND TITLE OF SIGNER (Type or print)<br>Marvin S. Haber<br>Vice President | 16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print)<br>Douglas C. Powell |

| | | | |
|---|---|---|---|
| 15B. CONTRACTOR/OFFEROR<br><br>(Signature of person authorized to sign) | 15C. DATE SIGNED<br>85/06/05 | 16B. UNITED STATES OF AMERICA<br>BY<br>(Signature of Contracting Officer) | 16C. DATE SIGNED<br>85/06/05 |

STANDARD FORM 30 (REV. 10-83) Prescribed by GSA FAR (48,cfr) 53.243 PREVIOUS EDITION UNUSABLE

# APPENDIX A

## ORDER FOR SUPPLIES OR SERVICES

Form Approved
OMB No. 0704-0187
Expires Jul 31, 1989

PAGE 1 OF 1

5. CERTIFIED FOR NATIONAL DEFENSE UNDER DMS REG 1: DO

1. CONTRACT/PURCH ORDER NO.
2. DELIVERY ORDER NO. 300-86-0001
3. DATE OF ORDER 86 MAR 15
4. REQUISITION PURCH REQUEST NO.

6. ISSUED BY: CODE
DEPARTMENT OF DEFENSE
Virginia Contracting Activity
P. O. Box 46563
Washington, D. C., 20050-6353
( ) -

7. ADMINISTERED BY: (If other than 6) CODE

8. DELIVERY FOB
[ ] DEST
[ ] OTHER
(See Schedule if other)

9. CONTRACTOR CODE FACILITY CODE
TELEPHONE ( ) -
NAME AND ADDRESS
CITY
STATE ZIP

10. DELIVER TO FOB POINT BY (Date)

11. MARK IF BUSINESS IS
[0] SMALL
[0] SMALL DISADVANTAGED
[0] WOMEN OWNED

12. DISCOUNT TERMS

13. MAIL INVOICES TO:

14. SHIP TO: CODE

15. PAYMENT WILL BE MADE BY: CODE

MARK ALL PACKAGES AND PAPERS WITH CONTRACT OR ORDER NUMBER

16. TYPE OF ORDER

DELIVERY [0] This delivery order is issued on another Government agency or in accordance with and subject to terms and conditions of above numbered contract.

PURCHASE [1] Reference your furnish the following on terms specified herein.
ACCEPTANCE. THE CONTRACTOR HEREBY ACCEPTS THE OFFER REPRESENTED BY THE NUMBERED PURCHASE ORDER AS IT MAY PREVIOUSLY BEEN OR IS NOW MODIFIED, SUBJECT TO ALL OF THE TERMS AND CONDITIONS SET FORTH, AND AGREES TO PERFORM THE SAME.

NAME OF CONTRACTOR SIGNATURE TYPED NAME AND TITLE DATE SIGNED

[ ] If this box is marked, supplier must sign Acceptance and return the following number of copies:

17. ACCOUNTING APPROPRIATION DATA/LOCAL USE

| 18. ITEM NO. | 19. SCHEDULE OF SUPPLIES/SERVICES | 20. QTY. ORD./ACCEPT.* | 21. UNIT | 22. UNIT PRICE | 23. AMOUNT |
|---|---|---|---|---|---|
| 1 | MICROCOMPUTER | 2 | EA | 1,895.00 | 3,790.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |
| | | 0 | | 0.00 | 0.00 |

*If quantity accepted by the Government is same as quantity ordered, indicate by X. If different, enter actual quantity accepted below quantity ordered and encircle.

24. UNITED STATES OF AMERICA
BY CONTRACTING/ORDERING OFFICER

25. TOTAL $ 8,781.50

29. DIFFERENCES $ 0.00

26. QUANTITY IN COLUMN 20 HAS BEEN:
[ ] INSPECTED [ ] RECEIVED
[ ] ACCEPTED, AND CONFORMS TO THE CONTRACT EXCEPT AS NOTED
DATE SIGNATURE OF AUTHORIZED GOVERNMENT REPRESENTATIVE

27. SHIP. NO.
[ ] PARTIAL
[ ] FINAL

28. D.O. VOUCHER NO.

30. INITIALS

31. PAYMENT
[ ] COMPLETE
[ ] PARTIAL
[ ] FINAL

32. PAID BY

33. AMOUNT VERIFIED CORRECT FOR
$ 0.00

34. CHECK NUMBER

35. BILL OF LADING NO.

36. I certify that this account is correct and proper for payment
/ /
DATE SIGNATURE AND TITLE OF CERTIFYING OFFICER

37. RECEIVED AT
38. RECEIVED BY
39. DATE RECEIVED
40. TOTAL CONTAINERS 0
41. S/R ACCOUNT NO.
42. S/R VOUCHER NO.

DD FORM 1155, JUL 87 Previous editions are obsolete. CONTRACTOR MUST SUBMIT FOUR COPIES OF INVOICE

## APPENDIX A

REQUEST FOR QUOTATIONS (THIS IS NOT AN ORDER) | The Notice of Small Business-Small Purchase Set-Aside on the reverse of this form [ ] is [ ] is not applicable. | PAGE 1 OF 1 PAGES

| 1. REQUEST NO. | 2. DATE ISSUED | 3. REQUISITION/PURCHASE REQUEST NO. | 4. CERT. FOR NAT DEF. UNDER BDSA REG. 2 AND/OR DMS REG. 1 | RATING |
|---|---|---|---|---|
| | / / | | | |

5A. ISSUED BY DEPARTMENT OF DEFENSE
Defense Logistics Agency DECASR BOS-Z
495 Summer Street
Boston, MA.
02210-2184

6. DELIVER BY (Date) / /

7. DELIVERY
FOB [ ] DESTINATION OTHER [ ] (See Schedule)

5B. FOR INFORMATION CALL: (Name and telephone no.) (No collect calls) ( ) -

8. TO: NAME AND ADDRESS, INCLUDING ZIP CODE
STATE: ZIP CODE

9. DESTINATION (Consignee and address, including ZIP Code)

10. PLEASE FURNISH QUOTATIONS TO THE ISSUING OFFICE ON OR BEFORE CLOSE OF BUSINESS (Date) / /

11. BUSINESS CLASSIFICATION (Insert the number 1 in appropriate boxes)
[ ] SMALL [ ] OTHER THAN SMALL [ ] DISADVANTAGED [ ] WOMEN-OWNED

IMPORTANT: This is a requst for information, and quotations furnished are not offers. If you are unable to quote, please so indicate on this form and return it. This request does not commit the Government to pay any costs incurred in the preparation of the submission of this quotation or to contract for supplies or services. Supplies are of domestic origin unless otherwise indicated by quoter. Any representation and/or certifications attached to this Request for Quotations must be completed by the quoter.

12. SCHEDULE (Include applicable Federal, State and local taxes)

| ITEM NO. (A) | SUPPLIES OR SERVICES (B) | QUANTITY (C) | UNIT (D) | UNIT PRICE (E) | AMOUNT (F) |
|---|---|---|---|---|---|
| 1 | MICROCOMPUTER | 2<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0<br>0 | | | |

| 13. DISCOUNT FOR PROMPT PAYMENT | 10 CALENDAR DAYS | 20 CALENDAR DAYS | 30 CALENDAR DAYS | CALENDAR DAYS |
|---|---|---|---|---|
| | % | % | % | % |

NOTE: Page 2 must also be completed by the quoter.

14. NAME AND ADDRESS OF QUOTER (Address, city, state, and ZIP Code)
STATE: ZIP:

15. SIGNATURE OF PERSON AUTHORIZED TO SIGN QUOTATION

16. DATE OF QUOTATION

17. NAME AND TITLE OF SIGNER (Type or print)

18. TELEPHONE NO. (Include area code)

NSN 7540-01-152-8084
PREVIOUS EDITION NOT USABLE

18-118

STANDARD FORM 18 (REV. 10-83)
Prescribed by GSA
FAR (48 CFR) 53.215-1(a)

# APPENDIX A

SECTION A - SOLICITATION/CONTRACT FORM

| | | | | |
|---|---|---|---|---|
| SOLICITATION, OFFER AND AWARD | 1. CERTIFIED FOR NATIONAL DEFENSE UNDER DDSA REG 2 AND/OR DMS REG 1 | | RATING | PAGE 1 OF 1 PAGES |
| 2. CONTRACT NO. M66032-83-B-0008 | 3. SOLICITATION NO. IFB RFP | 4. TYPE OF SOLICITATION [X] ADVERTISED (IFB) [ ] NEGOTIATED (RFP) | 5. DATE ISSUED / / | 6. REQUISITION/PURCHASE NO. M66032-85-B-0004 |

| | |
|---|---|
| 7. ISSUED BY: CODE<br>DEPARTMENT OF THE ARMY<br>Middle East/Africa Projects Office<br>X<br>P. O. Box 2250, 317 Battelle Drive<br>Winchester, Va., 22401-1450 | 8. ADDRESS OFFER TO (If other than Item 7) |

NOTE: In advertised solicitations "offer" and "Offeror" mean "bid" and "bidder".

## SOLICITATION

9. Sealed offers in original and ___ ___ copies for furnishing the supplies or services in the Schedule will be received at the place specified item 8, or if handcarried in the depository listed in until local time / / SEE SECTION L., Page (Hour) (Date)

CAUTION - LATE Submissions, Modifications and Withdrawals: See Section I Provision No. 52.214-7 or 52.210-10. All offers are subject all terms and conditions contained in this solicitation.

| | | |
|---|---|---|
| 10. FOR INFORMATION CALL | A. NAME: | B. TELEPHONE NO. (Include area code) (NO COLLECT CALLS) ( ) - |

11. TABLE OF CONTENTS



## OFFER (Must be fully completed by offeror)

NOTE: Item 12 does not apply if the solicitation includes the provisions at 52.214-14-16, Minimum Bid Acceptance Period.

12. In compliance with the above, the undersigned agrees, if this offer is accepted within calendar days (60 calendar days unless a different period is inserted by the offeror) from the data for receipt of offers specified above, to furnish any or all items upon which prices are offered at the price set opposite each item, delivered at the designated point(s), within the time specified in the schedule.

| 13. DISCOUNT FOR PROMPT PAYMENT (See Section I, Clause No. 52.232-8) | 10 CALENDAR DAYS | 20 CALENDAR DAYS | 30 CALENDAR DAYS | CALENDAR DAYS |
|---|---|---|---|---|
| | 0 % | 0 % | 0 % | 0 % |

| 14. ACKNOWLEDGMENT OF AMENDMENTS (The offeror acknowledges receipt of amendments to the SOLICITATION for offerors and related documents numbered and dated. | AMENDMENT NO. | DATE | AMENDMENT NO. | DATE |
|---|---|---|---|---|
| | | / / | | / / |
| | | / / | | / / |

| | | |
|---|---|---|
| 15a. NAME AND ADDRESS OF OFFEROR | CODE | FACILITY |
| 16. NAME AND TITLE OF PERSON AUTHORIZED TO SIGN OFFER (Type or print) | | |
| 15B. TELEPHONE NO. (Include area code) ( ) - | 15c. CHECK IF REMITTANCE ADDRESS [ ] IS DIFFERENT FROM ABOVE - ENTER SUCH ADDRESS IN SCHEDULE | 17. SIGNATURE |
| 18. OFFER DATE / / | | |

## AWARD (To be completed by Government)

| | | |
|---|---|---|
| 19. ACCEPTED AS TO ITEMS NUMBERED | 20. AMOUNT $ , , 0 | 21. ACCOUNTING AND APPROPRIATION |
| 22. SUBMIT INVOICES TO ADDRESS SHOWN IN (4 copies unless otherwise specified) | ITEM | 23. NEGOTIATED PURSUANT TO: [ ] 10 U.S.C. 2304(a)( ) [ ] 41 U.S.C. 252(c) ( ) |
| 24. ADMINISTERED BY (If other than Item 7) CODE | | 25. PAYMENT WILL BE MADE BY CODE<br>Department of the Army, Middle East/Africa Project Office<br>P. O. Box 2250, 317 Battelle Drive, Winchester, Va., 22401-1450 |
| 26. NAME OF CONTRACTING OFFICER (Type or print) | 27. UNITED STATES OF AMERICA<br>(Signature of Contracting Officer) | 28. AWARD DATE / / |

IMPORTANT - Award will be made on this Form, or on Standard Form 26, or by other authorized official written notice.

NSN 7540-01-152-8065 PREVIOUS EDITION NON USABLE 33-132 STANDARD FORM 33 (REV. 10-83) Prescribed by GSA FAR (48 CFR) 53.214(c)

# APPENDIX A

## AWARD/CONTRACT

1. CERTIFIED FOR NATIONAL DEFENSE UNDER DDSA REG 2 AND/OR DMS REG 1 — RATING — PAGE 1 OF 1 PAGES

2. CONTRACT (Proc.Inst.Ident.)NO. N66032-83-D-0008

3. EFFECTIVE DATE 05/01/85

4. REQUISITION/PURCHASE REQUEST NO./PROJECT NO. N66032-85-B-0004 ADPSO 83-50

5. ISSUED BY: CODE
DEPARTMENT OF THE NAVY
Naval Air Station
Supply Office (Code 1912)
Corpus Christi, TX.
W hi\ gto\ , D. C., 20202

6. ADMINISTERED BY (If other than Item 5) CODE N6603

7. NAME AND ADDRESS OF CONTRACTOR (No.street,city,county, state and ZIP Code)
FEDERAL DATA CORPORATION
CHEVY CHASE
STATE: MD ZIP CODE 20815

CODE — FACILITY CODE

8. DELIVERY
[ ] FOB ORIGIN [ ] OTHER (See below)

9. DISCOUNT FOR PROMPT PAYMENT
0
0
0

10. SUBMIT INVOICES (4 copies unless otherwise specified) TO THE ADDRESS SHOWN IN — ITEM

11. SHIP TO/MARK FOR CODE

12. PAYMENT WILL BE MADE BY CODE
U.S. Department of Education, Financial Management Service
400 Maryland Ave., S.W., Washington, D. C., 20202

13. THIS ACQUISITION WAS: (EnterX apl.box(s))
[X] A. ADVERTISED
B. NEGOTIATED PURSUANT TO: [ ] 10 USC 2304(A)( ) [ ] 41 USC 252(c)( )

14. ACCOUNTING APPROPRIATION DATA

| 15A. ITEM NO. | SUPPLIES OR SERVICES (B) | QUANTITY (C) | UNIT (D) | UNIT PRICE (E) | AMOUNT (F) |
|---|---|---|---|---|---|
| 1 | MICRO COMPUTER WITH HARD DISK | 3 | EA. | , 2,600 | , 7,800 |
| | | 0 | | , , 0 | , , 0 |
| | | 0 | | , , 0 | , , 0 |
| | | 0 | | , , 0 | , , 0 |
| | | 0 | | , , 0 | , , 0 |

15G. TOTAL AMOUNT OF CONTRACT > , 7,800

## 16. TABLE OF CONTENTS



### CONTRACTING OFFICER WILL COMPLETE ITEM 17 OR 18 AS APPLICABLE

17. [ ] CONTRACTOR'S NEGOTIATED AGREEMENT (Contractor is required to sign this document and return copies to issuing office.) Contractor agrees to furnish and deliver all items or perform all the services set forth or otherwise identified above and on any continuation sheets for the consideration stated herein The rights and obligations of the parties to this contract shall be subject to and governed by the following documents:(a) this award/contract,(b) the solicitation if any, and (c) such provisions representations, certifications, and specifications as are attached or incorporated by reference herein. (Attachments are listed herein.)

18. [ ] AWARD (Contractor is not required to sign this document.) Your offer on Solicitation Number including the additions or changes made by you which additions or changes are set forth in full above, is hereby accepted as to the items listed above and on any continuation sheets. This award consummates the contract which consists of the following documents: (a) the Government's solicitation and your offer,and (b)this award/contract. No further contractual document is necessary.

19a. NAME AND TITLE OF SIGNER (Type or print)

20A. NAME OF CONTRACTING OFFICER

19B. NAME OF CONTRACTOR
BY:
(Signature of person authorized to sign)

19C. DATE SIGNED / /

20B. UNITED STATES OF AMERICA
BY:
(Signature of person authorized to sign)

20C. DATE SIGNED / /

NSN 7540-01-52-8069 PREVIOUS EDITION UNUSABLE 25-106 STANDARD FORM 26 (RE.10-83) Prescribed by GSA FAR (48 CFR) 52.214(a)

# APPENDIX B

U. S. FEDERAL GOVERNMENT ORGANIZATIONS
THAT PARTICIPATED IN
"THE PAPERLESS PROCUREMENT SYSTEM", (TPPS)
AN OFFICE AUTOMATION PILOT PROJECT
FOR PROCUREMENT MANAGEMENT

1. Department of the Navy
Naval Air Engineering Center
Contracting Division
Bldg. 129, Attn:1945A
Lakehurst, NJ, 08733-5000

2. Department of the Navy
Naval Air Rework Facility
Attn: Code 33010, Bldg. LF-18
Norfolk, Va., 23511-5899

3. Department of the Navy
Naval Air Station
Attn: Code 60A
Dallas, Texas, 75211-9501

4. Department of Defense
Defense Logistics Agency
Defense Contract Administration
Services Region, Boston
Attn: Deputy Director Office
of Telecommunications
und Information Systems
DECASR BOS-Z
495 Summer Street
Boston, MA., 02210-2184

5. Department of Defense
Defense Logistics Agency
Defense Construction Supply
Supply Center
Attn: DCSC-PPS
Post Office Box 3990
Columbus, Ohio 43216-5000

6. Department of the Army
Jacksonville District,
Corps of Engineers
Chief, Procurement &
Supply Division
Post Office Box 4970
Jacksonville, Florida,
32232-0019

7. United States Department
of the Interior
National Park Service
Chattahoochee River
National Recreation Area
1900 Northridge Road
Dunwoody, Ga. 30338

8. United States Department
of the Interior
Bureau of Mines
Branch of Procurement -
Pittsburgh
Cochrans Mill Road
Post Office Box 18070
Pittsburgh, Pennsylvania
15236

9. United States Department
of the Interior
Fish and Wildlife Service
Contracting & General Services
Lloyd 500 Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregan, 97232

10. Department of Health
& Human Services
Director, Material Management
Carl Albert Indian Hospital
1001 N. Country Club Road
Ada, Oklahoma, 74820

11. Department of the Treasury
Internal Revenue Service Center
Central Region
ATTN: Contracts Centralized
Procurement
Staff RM:CP
P. O. Box 5365, Stop 65
Cincinnati, OH, 45201

12. U. S. Department of Agriculture
Agricultural Research Service
600 Mermaid Lane
Philadelphia, Pa. 19118

13. Department of the Navy
Navy Regional Finance Center
1931 Jefferson Davis Hwy.
Crystal City
Washington, D. C. 20371-51000

14. United States Office of
Personnel Management
San Francisco Region,
Seattle Area Office
Federal Building
915 Second Avenue
Seattle, Washington 98174-1080

15. U.S. Department of Agriculture
National Finance Center
P. O. Box 60,000
New Orleans, La., 70160

16. Defense Nuclear Agency
Director, Manpower
Management and
Personnel
Washington, D.C.,
20306-1000

17. Export-Import Bank of
the United States
811 Vermont Avenue, N. W.
Washington, D. C. 20571

## APPENDIX B

18. Deparment of Health and
    Human Services
    Health Care Finance
    Administration
    HCFA, Division of
    Administrative Systems

    6325 Security Blvd.,
    Room 2-F-1 ELR
    Baltimore, Md., 21207

19. Veteran's Administration
    Jerry L. Pettis
    Memorial Veterans Hospital
    ADP Site Manager (001A)
    11202 Benton Street
    Loma Linda, CA., 92357

20. General Services Administraton
    ORIM, 9KMT-10
    ATTN: Wayne A. Cutrell
    15th and C St., SW
    Auburn, Wa., 98001

21. Department of the Interior
    Bureau of Mines

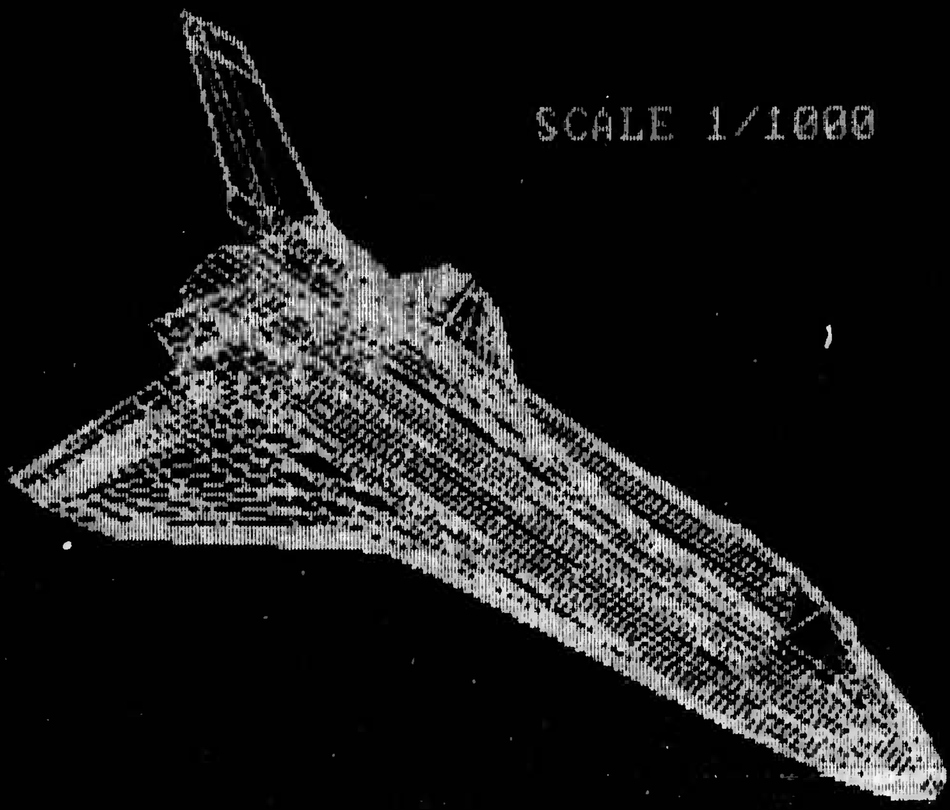
    Denver Colorado

22. Department of the Army
    Middle East/Africa Projects Office
    Corps of Engineers
    P. O. Box 2250
    Winchester, Virginia, 22401-1450

23. Department of the Treasury
    U. S. Customs Service
    National Logistics Center
    6026 Lakeside Boulevard
    Indianapolis, Indiana 46278

24. Department of Health &
    & Human Services
    National Cancer Institute-
    Frederick Cancer
    Research Facility
    (NCI-FCRF)
    Fort Detrick, Bldg 427, Rm. 11
    Frederick, Maryland 21701


# JEWELL TECHNOLOGIES, INC.



# THE PROGRAM MANAGER'S SUPPORT SYSTEM (PMSS)
# AN EXECUTIVE OVERVIEW
# AND
# DESCRIPTIONS OF FUNCTIONAL MODULES

by

Carolyn Bregard
Research Specialist

and

Harold J. Schutt
Director

## PREFACE

The Program Manager's Support System (PMSS) is an application of decision support systems technology to the defense acquisition program management environment.

The purpose of the PMSS is to provide a management tool for managers in a program management office (PMO), to assist them in their decision-making process, and to help them execute their project more effectively and efficiently.

The PMSS is intended to support the defense Program Manager and his/her first echelon staff; for example, the Chief Engineer, the Plans and Programs Officer, the Configuration Manager, the Integrated Logistics Support (ILS) Manager, etc. The PMSS also can be utilized by other managers in the acquisition community, for example, by headquarters level executives, program management officers in major projects, and field activity managers.

This Executive Overview is designed to acquaint you with the background, philosophy, and description of the PMSS, and provide you with descriptions of related functional modules. The Executive Overview is affectionately known as the 'Purple Book' to signify the multi-service nature of the program.

## EXECUTIVE OVERVIEW

## OF THE

## PROGRAM MANAGER'S SUPPORT SYSTEM (PMSS)

### The College

The Defense Systems Management College (DSMC) is a Department of Defense (DOD) institution dedicated to providing education to the defense acquisition community and, in particular, program management office (PMO) personnel. Education is provided in the program management policies, philosophies, skills, and techniques necessary for the effective and efficient execution of defense weapon systems acquisition projects.

In addition to its educational mission, DSMC has a research mission. Research in applied management science is conducted to support the above educational mission and to support the DOD acquisition community.

The third DSMC mission is dissemination of information, including software programs, to the DOD acquisition community.

DSMC also has a fourth mission, to provide oversight for education and training in the DOD acquisition community.

### A Need for Decisions

The defense systems acquisition process is a complex process comprising six decision-making disciplines, many functional areas of responsibility, and five acquisition phases. The defense program manager (PM), in executing an assigned program within this environment, is faced with many non-routine and unstructured decisions. Although management information systems (MISs) can provide the program manager with some of the information needed in the decision-making process, such systems predominately supply only historical data and current project status, usually with an abundance -- and many times an overabundance -- of unprocessed information. A need exists, therefore, to enhance the program manager's decision-making process by examining future courses of action, assisting in answering the 'What if....?' and 'Should I....?' questions, and distilling the available data into meaningful alternatives.

**One Solution**

A DSMC research project was established to address this need. This project applies decision support system (DSS) technology to the defense systems acquisition program management environment. This research project is called the Program Manager's Support System, or simply, the PMSS.

PROGRAM MANAGER'S SUPPORT SYSTEM

Figure 1

**What is the PMSS?**

A comprehensive depiction of the PMSS is contained in the PMSS logo shown in Figure 1.

The PMSS will:

-- Be an integrated software system operable on various hardware systems. The target hardware is low-cost microcomputers; e.g., the DOD standard microcomputer, the Zenith Z-248. (The system also is being designed to run on minicomputers.)

-- Provide a capability to 1) integrate program management functional areas of responsibility, 2) generate program alternatives and impacts caused by various management actions and technical activities, 3) assess these impacts on the program's functional areas, and 4) utilize other decision-making support methodologies.

-- Provide educational tools to facilitate the teaching of program management functions at educational institutions involved with defense systems acquisition program management.

The PMSS consists of two major parts, the integrated PMSS and functional modules.

-- The integrated PMSS is a manager's tool to assist the program manager in his/her decision-making process. It is NOT a management information system nor is it the decision-maker. The PMSS will permit the integration of the user's experience, judgment and intuition to allow the user to evaluate available alternatives and, ultimately, aid the user to make better, more timely decisions. A description of the integrated PMSS starts near figure 6.

-- Functional modules are software programs that can be used as stand-alone programs to assist in program management areas of responsibility such as planning, acquisition strategy development, program management plan generation, cost estimating, scheduling, Program Objectives Memorandum (POM) development, budget generation, budget execution monitoring, financial management, systems engineering, production planning, integrated logistics support planning, test issues identification, Test and Evaluation Master Plan (TEMP) generation, TEMP evaluation and monitoring, configuration management, document generation, document evaluation and monitoring, program office staffing and organization, etc. These modules support specific functions of program management operations.

**PMSS CHARTER**

- Support the School of Systems Acquisition Education in the development of curricula that implement the Program Manager's Support System (PMSS).
- Improve the decision-making process of defense program managers.
- Identify and understand the factors that affect and influence the decision-making process.
- Orient personnel in the defense program management environment in ways to improve the decision-making process.
- Provide information to the defense program management community to facilitate the decision-making environment.
- Encourage research in the decision science disciplines.
- Share accumulated knowledge with the decision sciences community.

Figure 2

**The PMSS Charter**

The PMSS project was conceived in-house in the DSMC Department of Research and Information (DRI) in early FY 1982. In August 1983, a PMSS Directorate was created within DRI to manage this project. The charter for the PMSS Directorate is shown in Figure 2.

The PMSS Directorate has now been renamed the Decision Support Systems (DSS) Directorate to reflect added responsibilities the directorate has assumed. The charter remains the same.

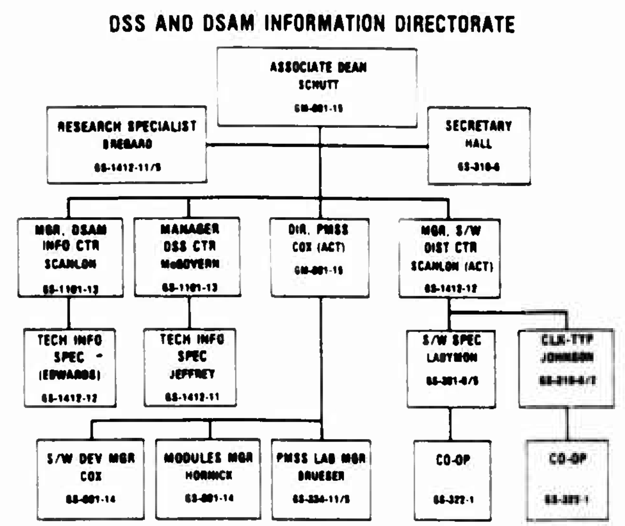



Figure 3

**Decision Support Systems Directorate**

The current organization of the DSS Directorate is shown in Figure 3.

The Manager, Defense Systems Acquisition Management (DSAM) Information Center is responsible for identifying, collecting, cataloging, distributing, and resource sharing of acquisition management information and materials. The DSAM Information Center functions as a hub of information for the defense acquisition community.

The Manager, Decision Support System (DSS) Center is responsible for identifying, collecting, cataloging, distributing, and resource sharing of information about decision support systems research projects and documents of interest to the defense acquisition community. The Manager, DSS Center also manages the Decision Support Systems Research Institute (DSS RI) which provides the network for resource sharing of DSS information.

The above two organizational elements of the DSS Directorate will not be addressed further in this overview. For additional information about them, contact the Director, DSS Directorate.

Having uncovered DSS items that can be used by the defense acquisition community, these are implemented in the PMSS software, managed by the Director of the PMSS group.

The Software Development Manager is responsible for the overall architecture -- the top-down approach -- which involves the development of the PMSS integrating software and related decision science research projects.

The Modules Manager is responsible for development of functional modules supporting the PMSS. Functional modules form a part of the integrated PMSS and also can be used individually. This represents the bottom-up approach in the PMSS development.

The PMSS Laboratory Manager is responsible for operations of the PMSS Laboratory (described later) and provides on-site software evaluation and support.

With software programs and documentation produced and ready for distribution, they are turned over to the Manager, DSMC Software Distribution Center. The purpose of the Software Distribution Center is to collect, catalog and distribute all software modules developed by the DSS Directorate and other organizational elements of DSMC.

The Research Specialist provides supporting research in the discipline areas affecting the PMSS project.

Hence, the DSS Directorate is developing the PMSS which includes the integrated system and the separate functional modules. As the system and modules are developed, the Directorate provides support in the use, refinement and operation of PMSS.

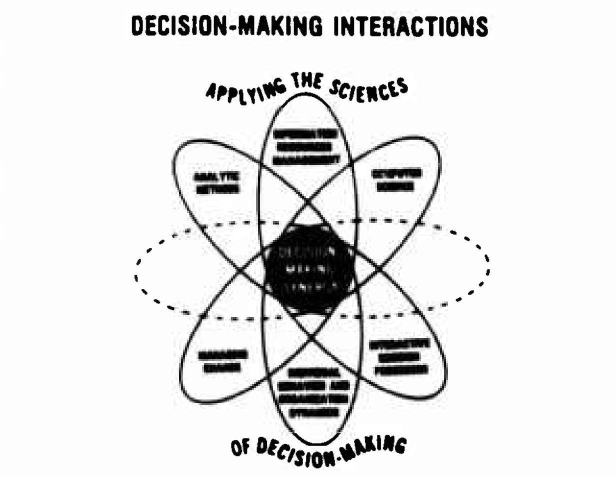



Figure 4

**Decision-Making Interactions**

The overall PMSS concept is delineated in Figures 4 and 5. The first element of the PMSS is shown in Figure 4.

Everyone makes decisions. Executing the results of that activity is sometimes an easy task, particularly if the decision only affects the decision-maker. At other times, it is a complex task involving the difficulties of getting other people to act in certain ways.

The primary disciplines that affect the decision-making environment in the modern, technologically oriented world are shown in Figure 4. These disciplines involve some 'hard technologies' -- analytical methods and computer science; 'soft technologies' -- interactive decision processes and individual behavior and organization dynamics, which bring the people into the process; and two 'umbrella philosophies' -- information resources management and managing change.

Of more importance than any of these individual disciplines is the impact of their interaction as they function together, and the synergy generated by those interactions. Hence, for a successful implementation of the PMSS, all of the above disciplines, and the interaction of these disciplines, must be appropriately integrated into the PMSS concept.

**PMSS CONCEPT**

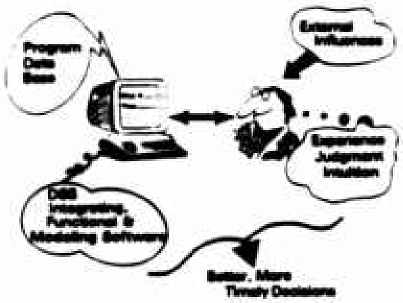


Figure 5

**PMSS Concept**

As depicted in Figure 5, the PMSS envisions the interactive use of a small, inexpensive computer system by a manager. The manager, in the context of the PMSS, may be the program manager, or functional area specialist or manager in the program management office. This would include, for example, the Chief Engineer, the Plans and Programs Officer, the Configuration Manager, the Integrated Logistics Support (ILS) Manager, etc. -- in other words, the first echelon staff of the PMO.

The PMSS will operate on a data base of program information which may be derived from extractions from the program management office's or supporting activities' MISs, or from direct inputs to the PMSS data base.

Various elements (decision support systems integrating software, functional modules, analytical models of several kinds) provided as part of the PMSS will operate on this data to permit the manager to ask 'What if....?' and 'Should I....?' questions and to generate alternative courses of action for his/her consideration. By integrating the results with the external influences imposed upon the program and by applying his/her experience, judgment and intuition, the program manager will be able to evaluate the available alternatives and, ultimately, make better and more timely decisions.

**PMSS PROGRAM OBJECTIVES**

- Modules/System for Classroom Use
- Modules/System for Operational Use
- PMSS Support
  - Software Packages
  - User/Programmer Manuals
  - Installation Assistance
  - Consulting
- PMSS Software Distribution
  - Maintain CM for Software

Figure 6

**PMSS Program Objectives**

The four basic objectives of the PMSS program are shown in Figure 6.

The first objective is to develop modules and the PMSS system for classroom use in the DSMC Program Management Course (PMC) and other DSMC courses, on campus and at DSMC regional sites.

The second objective is to develop modules and the PMSS system for use in program management offices and other activities of the defense acquisition community. As a part of the PMSS development process, program management office test sites have been selected to evaluate the modules before they are designated as operational modules.

The third objective is to develop materials necessary for a program management office to implement the PMSS as it is developed in the future. These include:

-- The software packages themselves, developed to operate on the current standard hardware configurations in the military services. These include the Zenith Z-248 and also the IBM PC/XT/AT and compatible microcomputers. For other special configurations, users should contact the DSS Directorate.

-- Complete user and programmer documentation. User manuals are provided with every software package. Programmer manuals are distributed only to those activities working on the applications. If a user is interested in working on a module for another application, contact the DSS Directorate.

-- Installation assistance is available if required. The DSS Directorate attempts to develop the user manuals so this is usually not necessary; however, sometimes assistance is required. In this regard, users finding problems with the documentation are asked to contact the DSS Directorate.

-- Finally, consulting on the PMSS and the capabilities it provides.

The fourth objective of the PMSS program is to establish the necessary capabilities for DSMC to perform configuration management functions for the PMSS in order to maintain control of the software and to ensure that all users can obtain maximum utility of the PMSS software. Recommendations for changes and improvements to the PMSS from all sources are welcomed and solicited. The DSMC has established the Software Distribution Center to maintain configuration control of the system to ensure maximum usefulness for all who need the system. Recommendations for additions and/or changes to DSMC software and documentation should be forwarded to the Manager, DSMC Software Distribution Center.

**DEFENSE PROGRAM MANAGER'S RESPONSIBILITIES**

- Functional Areas
  - Administrative Management
  - Program Overview/Status Management
  - Project Planning
  - POM Development and Budgeting
  - Financial Management
  - Contracting
  - Government Activity Tasking
  - Technical Management
  - Configuration Management
  - Integrated Logistics Support
  - Deployment and Operational Status
- Capabilities
  - Risk Management
  - Cost Estimating
  - Scheduling
  - Monitoring

Figure 7

**Defense Program Manager's Responsibilities**

One of the initial activities of the PMSS project was to conduct a survey of DOD program managers to examine their information requirements and existing information systems. This resulted in the definition of the 11 program management functional areas of responsibility and the need for the four capabilities shown in Figure 7.

This breakout, including all subfunctions falling within each area, represents overall responsibilities of the defense program manager and was used to formulate the base line for the initial PMSS design

**Defense Program Manager's Decision-Making Methodology**

As part of the analysis of the program manager's modus operandi, a Program Manager's Action Model was developed to delineate the manner in which a program manager functions. From this analysis evolved the information categories used when solving problems. These categories include administrative information and programmatic information. Administrative information is related to the functioning of the program management office such as personnel, organization and security.

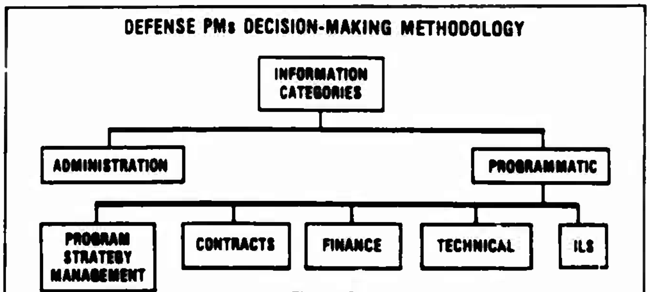


Figure 8

Programmatic information is specifically associated with the program and can be further categorized into the areas of program strategy management, contracts, finance, technical, and ILS as shown in Figure 8.

In the analysis of the program manager's functions, it evolved that he/she frequently superimposes a 'management perspective template' over the programmatic information when a program decision is required. That program management template (or filter) looks at the information with a view toward how the 'current situation' affects the cost, schedule, performance and supportability of the program. These four areas -- cost, schedule, performance and supportability -- establish the uppermost level of requirements for the program manager's decision-making methodology.

A comprehensive analysis of 1) the program manager's responsibilities, 2) needed capabilities, 3) information categories, and 4) management areas affecting the decision-making methodology, provided the base line for the design of the integrated PMSS.

The integrated PMSS will provide a management tool for the program manager and key staff members to use in the decision-making process. The PMSS tool will, when completed, support the program management process in all stages of program management; that is, birth of the program through concept exploration/definition, concept demonstration and validation, full scale development, full rate production/initial deployment, operations support and, finally, retirement of the system. The PMSS will support this acquisition process by providing an automated tool to support decision-making activities during the acquisition process.

**PMSS Overall Approach**

Two simultaneous approaches are being employed to develop the PMSS. A top-down approach is providing the overall architecture design -- the boundaries of the system, what can be accomplished and, equally important, what cannot be accomplished. This includes the development of integrating software for the integrated PMSS. A bottom-up approach also is being executed. This concerns development of functional modules which, when integrated together, provide the main PMSS functionality. Figure 9 depicts these two approaches which will be integrated as the PMSS evolves from stage to stage.

**PMSS OVERALL APPROACH**

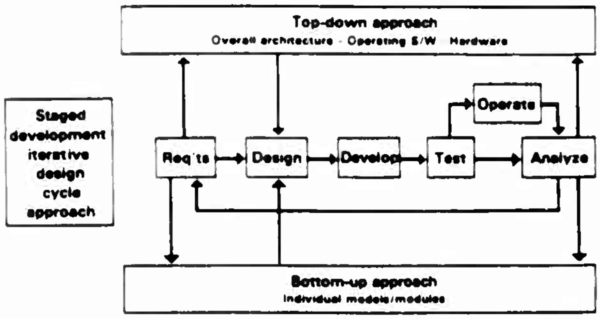



Figure 9

In addition, Figure 9 outlines a third key approach being used in the PMSS development process. That is the use of the staged development iterative design cycle approach or, for short, the iterative design cycle.

The iterative design cycle approach is to build a 'small' system addressing a portion of the problem, use and test it, reevaluate the requirements, redesign the system, rebuild it, and repeat this process until the system is as required. The designer/builder and the user work side-by-side to develop the system.

There are many approaches to the development of decision support systems. Some are successful; some are not. In general, however, those that followed the iterative design cycle approach have been successful. Therefore, based on that track record, and the unstructured/semistructured and changing characteristics of the program manager's decision-making processes, this approach is being employed in the development of the PMSS.

The following sections address the design and development of the integrated PMSS and the functional modules. The integrated PMSS will include capabilities, in addition to the integration of the functional areas of program management, to provide convenient support to the user of the PMSS.

**PMSS SOFTWARE DEVELOPMENT CONTRACT EVOLUTIONARY PHASES**

- Operational PMSS Definitization
- PMSS Software Development
  — 3 Tasks
- Functional Module Development
  — 2 Tasks
- Program Impact/Functional Module Integration
  — 3 Tasks
- Final Test and Demonstration

Figure 10

**PMSS Software Development Contract Evolutionary Phases**

In FY 1983, three parallel, competitively awarded contracts were executed to develop the PMSS architecture. The results were consolidated by DSMC into the requirements for the PMSS software development contract.

A competitively awarded contract for the PMSS software development was executed in 1984. It contained a number of tasks to be performed over several years, representing various evolutionary phases as shown in Figure 10.

An initial task addressed the definitization of the operational PMSS. Several additional tasks concentrated on the PMSS software including the basic architecture, user interface, resource manager, and decision support kernel. These tasks addressed separately a prototype linked software system to be used to test and refine concepts, and an integrated software system that incorporated the results from the prototype.

Other tasks concentrated on the development of specific functional modules and the program impact advisor. A final task addressed test and evaluation.

In late 1988, an Alpha Test version of the PMSS was delivered. The Alpha Test version does not include all of the functionality, fully integrated, that will be in the operational PMSS. This test version is undergoing evaluation, both at DSMC and at selected PMOs, with the goal of identifying any problems or enhancements that must be incorporated prior to formal distribution. Subsequent versions of the PMSS will incorporate more functions that are fully integrated.

**PMSS Software Architecture**

The PMSS is designed along the lines of a decision support system (DSS) with three major elements: a user interface, a model (or function) base, and a data base. The software architecture, shown in Figure 11, consists of a User Interface/Executive, a Resource Manager, an External Interface, and a Decision Support Kernel.

The PMSS user will interface with the PMSS through the user interface/executive which will include seven submodules: input manager, goal manager, performance monitor, process manager, view manager, output manager, and help and user aids. The resource manager, acting as an interface between the decision support kernel, external interface, and user interface, coordinates commands and allocates hardware resources.

The decision support kernel is the heart of the PMSS. It will contain a kernel process/integration manager, function (model) base manager, and knowledge base manager in

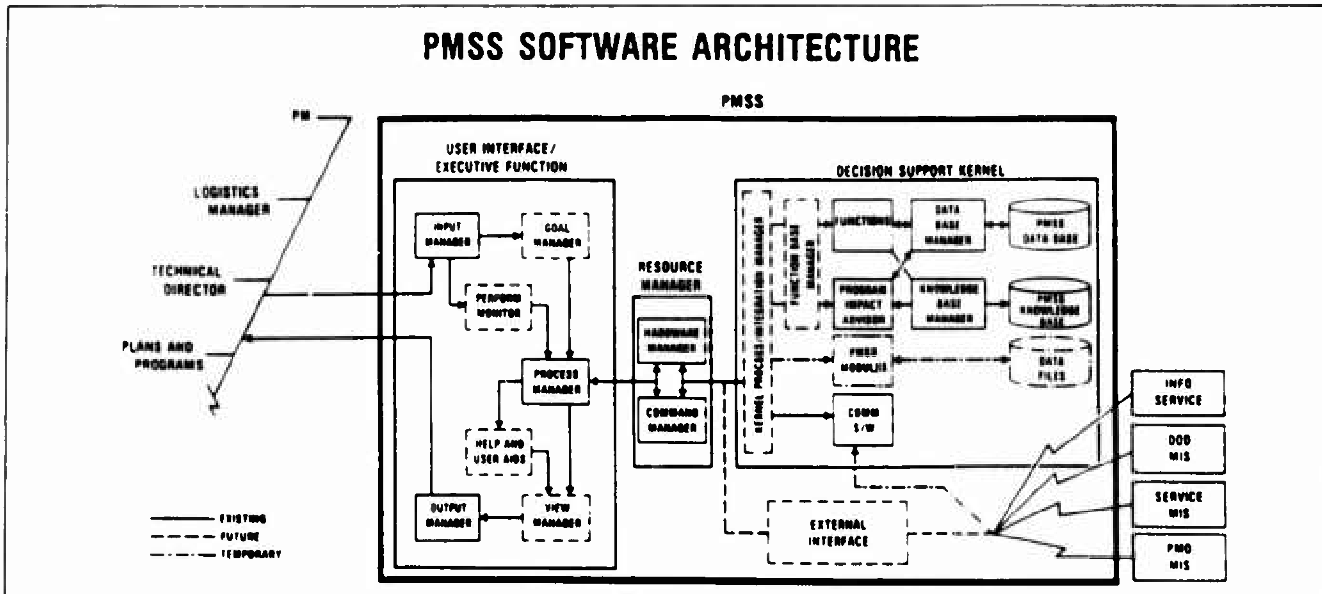



Figure 11

addition to the data base, data base manager, knowledge base, functions, program impact advisor, and other software. Applications of artificial intelligence have been applied to the program impact advisor.

The external interface will provide the program manager the capability to query other automated systems ranging from the program management office's own management information system to external information services such as the Defense Technical Information Center (DTIC), Compuserve, etc. The external interface may also be used to update the PMSS data base from other DOD and Service management information systems.

**PMSS Unique Characteristic**

Many management information systems have been developed to support specific functional areas of responsibility; e.g., budgeting, configuration management, ILS, etc. These MISs support key people in the program management office and assist them to perform their duties.

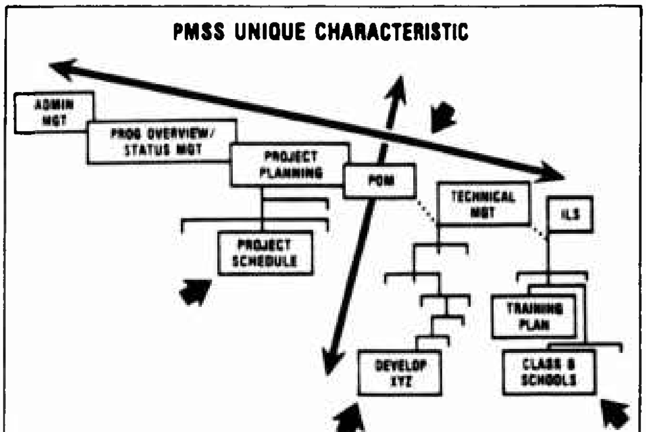



Figure 12

An integrated decision support system has not yet been developed that extracts and integrates data from all these functional areas in support of the program manager/program management office decision-making process. Yet, the program manager is concerned with all elements of his/her program and needs to see the 'big picture' and know the impact of one area on another.

This is the unique characteristic that is a key part of the PMSS concept. As depicted in Figure 12, it is the capability to assess rapidly the impact of program perturbations both across and within all functional areas of program management responsibility as related to the program manager's decision-making areas of interest.

This program impact advisor function -- the integration across and within all areas of concern to the program management office -- is the unique and most important function of PMSS.

On the next few pages, the integrated PMSS, or as it is simply called, the PMSS, will be described.

**PMSS Functions**

In order to support the decision-making efforts of the program manager and his/her staff, the PMSS provides the seven basic functions listed in Figure 13.

The Program Overview/Status function provides the capability to easily assess the program status, based on the six information categories described previously, as compared to cost, schedule and performance, and to quickly find the data that are driving the status.

Program Impact Advisor, perhaps the most important PMSS function, provides the capability to rapidly assess the impact of program perturbations both across and within

PRIMARY FUNCTIONS OF THE INTEGRATED PROGRAM MANAGER'S SUPPORT SYSTEM

- Program Overview/Status
- Program Impact Advisor
- Functional Analysis/Support
- Information Category Data
- Independent Modules
- Executive Support
- Utilities

Figure 13

the areas of interest to the program manager/program management office.

The Functional Analysis/Support function is a set of functional capabilities that allows the program manager and staff to enter and manipulate program data in each functional area. Such functions as Work Breakdown Structure, PERT Networking, Critical Path Analysis, Gantt Milestone Scheduling, Budget Planning, Budget Preparation, Budget Tracking, and Budget Execution Monitoring are included.

The Information Category Data function provides quick access to the program data via the six information categories. The data are presented in standard reporting format wherever possible.

Independent Modules is a capability for the user to directly access software that does not use the PMSS data base. Two categories of software are supported: PMSS Functional Modules that have not yet been integrated into the PMSS architecture, and commercial software packages that the user can install via a PMSS utility function.

The Executive Support function provides assistance with routine tasks each program manager performs. These functions include capabilities such as a calendar, telephone/address list with automatic dialer, and action item and travel status.

The PMSS Utility function provides both Program Management related and PMSS System Administration related utilities. Included in the Program Management utilities are the Brief, an audit trail of all changes made to the PMSS data base, the capability to change the Project being worked on, and access to the Escalation Indices.

System Administration functions include the capability to archive the Brief data, Backup/Unload and Restore/Load the PMSS data base, select screen colors, define the hardware configuration, and a Supervisor function where users, projects, and read/write access are controlled.

In most cases, standard DOD/Service or other sample data is provided by the PMSS as a base line from which the manager can tailor his/her own program.

PROGRAM OVERVIEW/STATUS

- Red, Yellow and Green Arrow Indicators
- Information Category/ Cost-Schedule-Performance-Matrix
- Text Explanations
- Related Data Screens List with Status
- Direct Access to Problem Data
- Data Color Coded

Figure 14

**Program Overview/Status**

The Program Overview/Status function provides the capability to easily assess the program status based on the six information categories described previously as compared to cost, schedule and performance, and to quickly find the data that is driving the status. This is outlined in Figure 14.

Red, yellow and green arrow indicators are given for each of the categories in terms of cost, schedule, and performance. These indicators are based on criteria that is adjustable by the program manager. After selecting a category of interest, the user can select either an explanation of the status, presented in text, or one of the related data screens. The explanation will incorporate the actual project data in the text.

A listing of data screens that affects the category of interest is presented, each with its own status indicator. The user can select a data screen of interest, such screens generally being formatted after standard reporting formats. The data itself in each data screen is color coded red, yellow and green to show status. The user can enter weights for each data item to control how much each data item affects the status indicators.

Control over the overall status indicators is maintained through color coded 'thermometers'. The user can adjust the thresholds on these thermometers where the status indicators change colors. The value of the data related to each category is shown to facilitate adjustment of the thresholds.

**Program Impact Advisor**

Program Impact Advisor, perhaps the most important PMSS function, provides the capability to rapidly assess the impact of program perturbations both across and within the areas of interest to the program manager/program management office.

This function, as shown in Figure 15, consists of an expert system that assists the program manager in responding to unplanned changes. It can also be used for program planning by testing possible program conditions and analyzing the potential

**PROGRAM IMPACT ADVISOR**

- Expert System Application
- Assists with "What if . . .? " and "Should I . . .?" Questions
- Analyzes Real or Potential Program Perturbations
- Looks at Entire Life Cycle
- Results Presented in Text
- Proposes Solutions in Terms of Specific Cost and Schedule Changes
- Highlights High Risk Areas

Figure 15

**FUNCTIONAL ANALYSIS/SUPPORT**

- Work Breakdown Structure
- PERT Network
- Critical Path Analysis
- Gantt Milestones
- Budget Planning
- Budget Preparation
- Budget Tracking
- Budget Execution Monitoring

Figure 16

resultant impacts. Putting it another way, the Program Impact Advisor function assists with the 'What if ...?' and 'Should I ... ?' questions.

Program schedule changes are entered as changes to task durations or task precedences. Task precedences are changed graphically on the screen by the user adding, deleting, or moving tasks in the PERT network. Cost changes are entered at the task level and rolled up by the system, and funding changes are entered at the Appropriations level.

A set of five scheduling priorities can be rank ordered to tell the system how to evaluate your program. The Evaluation is then invoked, and can address either constant dollars or inflated dollars. The results are presented in a report that explains in text problem areas and potential solutions. Specific schedule and cost data are presented. High risk areas are also addressed.

A number of different sets of data can be saved as 'Scenarios' and called back later. Any scenario can also be designated as the new base line when proposed changes are approved.

**Functional Analysis/Support**

The Functional Analysis/Support function is a set of functional capabilities that allows the program manager and staff to enter and manipulate program data in each functional area. Such functions as Work Breakdown Structure, PERT Networking, Critical Path Analysis, Gantt Milestone Scheduling, Budget Planning, Budget Preparation, Budget Tracking, and Budget Execution Monitoring are included as shown in Figure 16.

The Work Breakdown Structure function provides the capability to create and modify a work breakdown structure for your program. MILSTD-881-A WBSs are included in the PMSS, and can be called in and modified as required.

PERT Networking allows the creation of a PERT network for your program. A DOD generic life cycle PERT network is included in the PMSS and can be called in and modified, or a PERT network can be created from a blank screen. The user adds, modifies, and deletes Tasks and precedence lines graphically on the screen. The system will tell the user if improper relationships have been created. Program start and end dates, and Task durations are entered, and the system calculates the critical path and planned Task start and end dates. The critical path is shown in red. The PERT network can be plotted out to a plotter in color.

The Gantt milestone chart shows all tasks on a time scale. Each task is color coded to represent status the same as the Program Overview/Status function. The time scale can be quickly changed to years, quarters, months, or weeks. The tasks can be sorted by name, number, start date, or end date. The Gantt milestone chart can be plotted out to a plotter in color.

The Budget Planning function allows the selection of Appropriations (all DOD appropriations are included in the PMSS), assigning Program Elements or Line Item numbers, designating Performing Activities, and tying any or all of these attributes and the WBS to the Tasks created with the PERT function. In addition, individual Task costs and risk can be entered.

The Budget Preparation function provides roll ups of all costs by Appropriation, Program Element or Line Item, Performing Activity, Work Breakdown Structure, and Task. These roll ups represent the budget requirements of the program.

Budget Tracking allows the user to track the budget process and serves as an audit trail of funding changes throughout the budget cycle. Budget Execution Monitoring allows the tracking of commitments, obligations, and expenditures, and can be accessed by Appropriation, Program Element/Line Item, Performing Activity, Work Breakdown Structure, or Task.

**OTHER RELATED PMSS FUNCTIONS**

- Information Category Data
- Independent Modules
- Executive Support
- Utilities

Figure 17

**Other Related PMSS Functions**

The PMSS contains additional capabilities to help the user with various tasks associated with program management. The Information Category Data function allows quick access to all of the program data through a hierarchical menu structure that represents the hierarchical PMSS data structure. The data is contained on Data Screens which are generally formatted in accordance with standard reporting requirements.

Independent Modules provides the capability to access software that is not integrated into the PMSS data base. PMSS Functional Modules that have not yet been integrated are included. The user can also install, through a PMSS utility, most commercial packages such as word processors, spreadsheets, and presentation graphics. This capability allows the program manager to use related management aids, modules, spreadsheets, word processors, etc. without leaving the PMSS environment.

Executive Support provides several administrative type functions that are normally performed on a day to day basis. These include a calendar function with a three month display, daily schedule, and note pad. A name and address function is available with automatic dialing capability. Travel status information can be maintained, and a tickler system is included to help keep track of action items.

The PMSS Utilities include both Program Management functions and System Administration functions. Here is where the user can change the project that is loaded into PMSS, update Escalation Indices, and view the Brief which is an audit trail of all changes made to the PMSS data base. System Administration functions include the capability to archive the Brief data, Unload/Backup and Load/Restore the PMSS data base, change the colors of the screen display, and perform System Supervisor functions such as setting read/write access to the data base.

**PMSS Implementation at DSMC**

The development and implementation of PMSS will primarily concern two facilities as shown in Figure 18.

A major research objective of the PMSS program is to remain aware of, and up-to-date on, software that has been developed by other activities and which may be of use in the PMSS program or to the DOD acquisition community. Another objective is to test out PMSS software as it is developed. These

**PMSS IMPLEMENTATION AT DSMC**

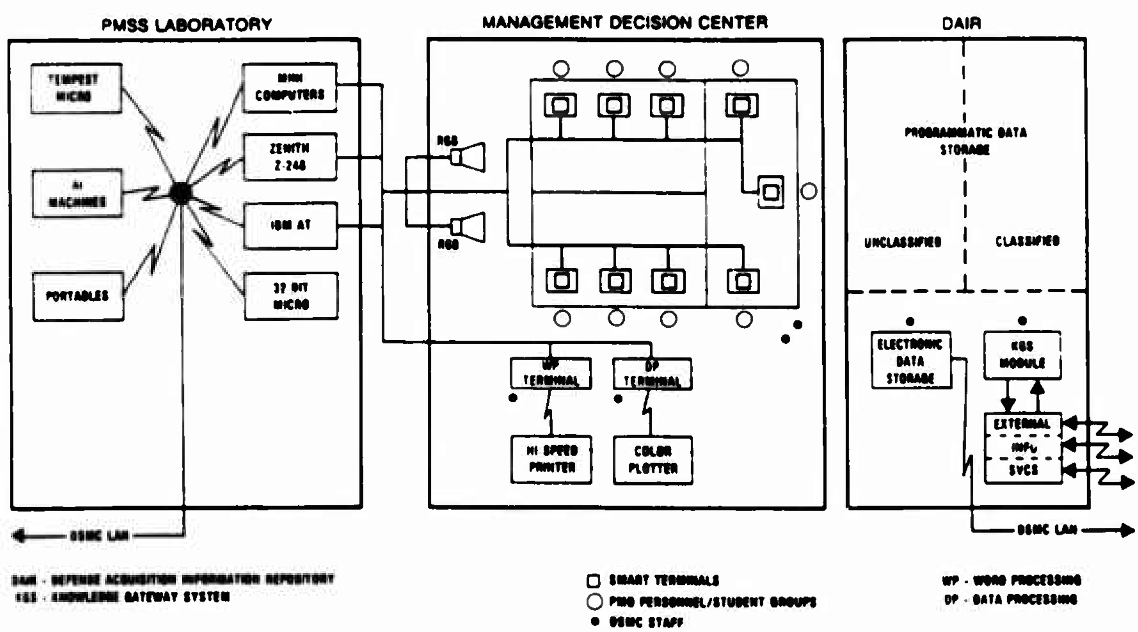



Figure 18

requirements lead to the development of the PMSS Laboratory. The purpose of the laboratory is threefold: first, to test the PMSS concept; second, to have a facility to design, build, debug, test, and operate modules of the PMSS; third, to test the microcomputer capabilities and capacities in the PMSS environment. Standard, off-the-shelf software packages will be tested in the laboratory for potential application in the PMSS environment, and for use in the DOD acquisition community.

A second facility that relates to the PMSS program is the DSMC Management Decision Center (MDC). The MDC will be used by student groups to solve classroom exercises, by program managers and their staffs to solve program problems and/or by other management executives to do policy formulation and/or types of management decision exercises. In any of the cases, users bring the technical content of their problems and exercise them by using the decision supporting tools that are available in the MDC. One of these tools will be the PMSS. Users are supported by facilitators assisting in the process portion of problem-solving.

A third element that will be necessary to support the use of PMSS at DSMC will be the Defense Acquisition Information Repository (DAIR). The DAIR will consist of the collection of programmatic data on selected defense system programs that provide the necessary data base for operation of the modules and PMSS.

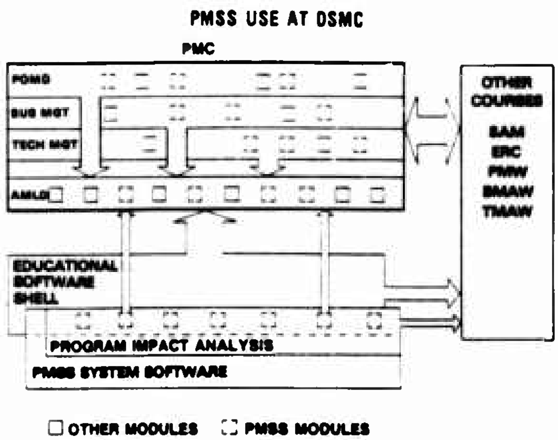



Figure 19

**PMSS Use at DSMC**

At DSMC, the Program Management Course (PMC) is the primary educational vehicle. Students acquire knowledge and learn skills about program management from three departments in the college: Policy and Organization Management, Business Management, and Technical Management. Students integrate and apply these knowledges and skills in the PMC Simulation Department. In their educational environment, students run the full spectrum from attending lectures to conducting exercises.

The PMSS modules and integrated system can be used to complement the educational experience by providing a management tool for the student to use to conduct his/her classroom and laboratory exercises. The PMSS provides the software tool to aid the student in the solution of the management problem. In that respect, the DSMC student is using the PMSS in the same way he/she will use PMSS as an action officer in a program management office or other activity of the acquisition community.

The PMC course has been revised to teach program management material in two segments. The first segment is a 6-week program concerning fundamental knowledge and skills of program management. The second segment, lasting 14 weeks, places the student in a simulated program management office environment and teaches how to do program management by having him/her progress through the life cycle of a simulated project.

The PMSS is being designed to provide the software management tool to support the simulated program management project. The PMSS can be used in the other DSMC courses in the same manner as shown in Figure 19.

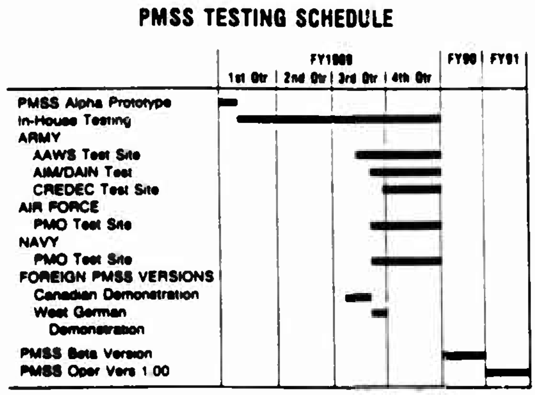



Figure 20

**PMSS Testing Schedule**

The PMSS testing schedule is shown in Figure 20. Modules are being developed and initial products from these developments are being delivered. Program management offices are invited to submit requirements for new, needed software support; to send requests for development of the planned modules; or to send requests for refinements of prototype or operational modules.

At the present time several modules are in distribution, several are in in-house testing and will be released for distribution shortly and others are still in development. Descriptions of these modules are included in the next portion of this overview.

The first alpha prototype of the integrated PMSS has been delivered and is undergoing in-house testing. This prototype will be used at selected program management offices in the Army, Navy and Air Force to commence field testing of the system. Refinements to the alpha version will be made during the rest of FY 89. In early FY 90, a beta-test version will be available for distribution to additional program management offices.

**PMSS MODULES DESIGN**

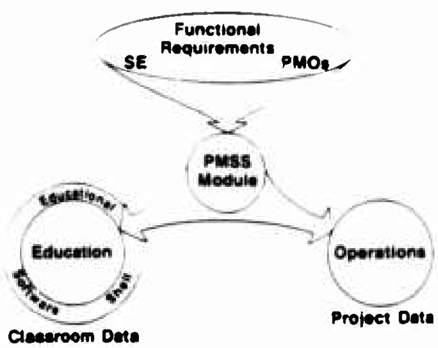



Figure 21

### PMSS Modules Design

The PMSS modules, supporting various functions of the program management office, are being designed for dual usage, as shown in Figure 21. Modules will be used in educational environments at DSMC and other DOD educational institutions. Modules used for this purpose may require minor modification for teaching applications. Data appropriate to the local education environment will have to be input for use of the modules in the classroom. The other purpose for the modules is, of course, for operational use in program management offices. Here a particular program's actual data will provide the data source for operation of the PMSS.

To the maximum extent possible, the desire is that modules designed for these two purposes be alike so that as students move from the classroom to their operational assignments they will see and use the same process in a particular application. Therefore, for the design portion of PMSS module developments, requirements are gathered from the DSMC School of Systems Acquisition Education (SE) and from program management offices. Modules at this stage are called "planned."

### PMSS Modules Implementation

After development, PMSS modules undergo a substantial amount of testing before they are declared "operational." Several program management offices have volunteered to be PMSS test sites. During the development process, the contractor's progress is reviewed through progress reviews and demonstrations which are given to DSMC faculty and representatives from the program management office test sites. Comments and recommendations are fed back into the development process as shown in Figure 22.

**PMSS MODULES IMPLEMENTATION**

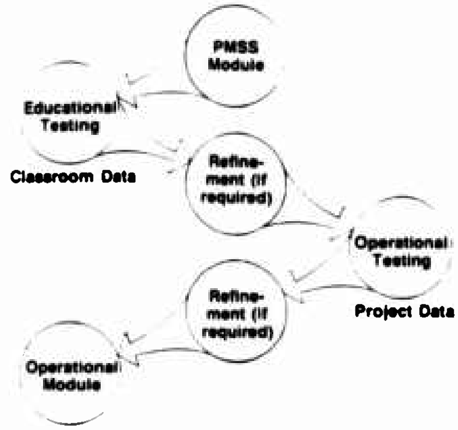



Figure 22

When the module is "completed" to the prototype stage, as an initial alpha-test version, it is tested at DSMC and refinements are made, if required. Then, the module is subjected to beta-test field testing and, again, refinements are made if required.

When the module is considered operational, it is given to the Manager, DSMC Software Distribution Center, for distribution.

Further refinements/modifications still can be made, as necessary, to meet users' needs. Changes at this stage normally are funded by the requesting user.

Hence, modules are designated as in testing and distribution, in development, or planned. A summary table of the PMSS modules is contained in Table 1. More detailed descriptions of these functional modules follow Table 1.

### DSMC Software Distribution Center

The purpose of the DSMC Software Distribution Center is to collect, catalog, and distribute all software modules developed by the DSS Directorate and other organizational elements of DSMC.

The Software Distribution Center provides software modules to be used in the classrooms at DSMC and to program management offices (PMOs). The software is intended to aid in the planning, programming, execution, and monitoring of defense weapons systems programs. The PMOs, for whom the software is developed, are those in the DOD acquisition community. However, any government agency which can demonstrate a valid need for this software can receive copies. Requests should be sent to:

Defense Systems Management College
ATTN: DRI-S (Software Distribution Center)
Fort Belvoir, VA 22060-5426
(703) 780-1850 or Autovon 354-5783

TABLE 1

| NAME OF MODULE | SHORT NAME | BRIEF PURPOSE | STAGE | EQUIPMENT | PAGE |
|---|---|---|---|---|---|
| **MODULES IN TESTING AND DISTRIBUTION** | | | | | |
| Contract Appraisal System | CAPPS | Monitor contract cost performance | Operational | IBM-PC; Z-248 Z-120 | 45 |
| Cost Analysis Strategy Assessment | CASA | Conduct LCC analysis | Operational | IBM-PC; Z-248 Z-120 | 45 |
| Competition Evaluation Model | CEM | Conduct production competition analysis | Operational | IBM-PC; Z-248 Z-120 | 46 |
| Software Cost Estimating | SWCE | Develop cost estimate for software developments | Prototype | Z-248[1] | 47 |
| Government Activity Tasking | GAT | Generate and monitor tasking to government activities | Prototype | IBM-PC; Z-248 | 48 |
| Procurement Strategy Module | PSM | Select a procurement stragegy | Prototype | IBM-PC; Z-248 | 48 |
| Schedule Risk Assessment Management | SCRAM | Network development Milestone management Schedule risk assessment | Prototype | IBM-PC; Z-248 | 49 |
| Executive Support System | ESS | Day-to-day administrative functions | Prototype | IBM-PC; Z-248 | 49 |
| Quick Cost | QUIKCOST | Conduct quantity/cost trade-off analysis | Prototype | IBM-PC; Z-248 | 50 |
| Program Office Organization and Staffing | PROS | Develop PMO organization charts, on board counts | Prototype | IBM-PC; Z-248 | 50 |
| Expert System for Acquisition Strategy | ESAS | Assist in writing acquisition strategy | Prototype | Z-248 | 51 |
| Procurement Document Generator | PDG | Development and maintenance of procurement documentation | Prototype | Z-248 | 51 |
| Parametric Cost Estimating | PACE | Conduct parametric cost estimates | Prototype | IBM-PC; Z-248 Z-120 | 52 |
| Schedule and Resource Allocation | SARA | Develop Gantt chart schedule; do resource allocation | Prototype | Z-248; Z-120 | 53 |
| Automated Program Planning and Documentation Module | APPDM | Generation and monitoring of PMP; PS/P; TEMP; SEMP; ILSP; RAMP | Prototype | IBM-PC; Z-248 | 54 |

The DSMC Software Distribution Center puts out an update report to keep users and potential users informed about new software modules, new versions of existing modules, and any changes or announcements of interest. If you are interested in receiving these updates, please contact the address listed above.

**In Summary**

The above discussion presents an executive overview of the PMSS. The ultimate purpose of the PMSS is to aid the program manager in the effective and efficient management of his/her project through education and direct use. Therefore, we welcome your comments and suggestions.

## TABLE 1 (CONTINUED)

| NAME OF MODULE | SHORT NAME | BRIEF PURPOSE | STAGE | EQUIPMENT | PAGE |
|---|---|---|---|---|---|
| Budget Preparation and Execution | BP&E | Develop budgets<br>Monitor progress | Prototype | IBM-PC; Z-248 | 54 |
| Venture Evaluation Review | VERT | Simulates decision environments under risk | Prototype | IBM-PC; Z-248 | 55 |
| **MODELS IN DEVELOPMENT** | | | | | |
| Parametric Cost Estimating Relationships | PACER | Collection of cost estimates relating to cost factors | Prototype | IBM-PC; Z-248 | 55 |
| Document Keyword Search | DOKS | First phase of document configuration control | Prototype | IBM-PC; Z-248 | 56 |
| Test Issues Management Evaluation | TIME | Conduct pre-TEMP planning | Protoype | IBM-PC; Z-248 | 56 |
| **OTHER MODULES** | | | | | |
| Decision Styles/Information Usage Research | DSI | Determine users' decision styles | Development | IBM-PC; Z-248 | 56 |
| Project Control System | PCS | Financial control system | Prototype | IBM-PC; Z-248[2] | 57 |
| Small (or Service) Contract Cost Performance System | SCCPS | Monitor contract performance | Development | IBM-PC; Z-248 | 58 |

**MODULES PLANNED**

Production Planning
Contract Management
SAR Generator
Initial Spares/Replenishment Spares Planning
Travel Management
Administrative Management
Checklists
P3I Planning

[1]Needs Symphony Version 1.1 to run; not provided with module

[2]Needs Lotus 1-2-3 Version 2.0 to run; not provided with module. Requires customization per site.

*IBM-PC means IBM-PC, IBM-XT, Z-150, or compatibles
*Z-248 means Z-248, IBM-AT, or compatibles
*Z-120 means Z-120 (Z-100) only

Specific availabilities will be published in DSMC Software Distribution Center Quarterly Update

Please send them to:

Mr. Harold J. Schutt
Director, DSS Directorate (DRI-S)
Defense Systems Management College
Fort Belvoir, Virginia 22060-5426

or call us at (703) 664-5783/4113, or Autovon 354-5783/4113.

# HUMAN RESOURCES

HUMAN RESOURCES

# CHARACTERISTICS OF ACQUISITION PERSONNEL

**Michael G. Krause**
**Defense Systems Management College**

ABSTRACT

This paper reports on research into the patterns of brain dominance and psychological type of a sample of acquisition management personnel attending the Program Management Course at the Defense Systems Management College. The primary Myers-Briggs Type Indicator groupings are ISTJ, ESTJ, INTJ, and ENTJ; and the primary Herrmann brain dominance groupings are cerebral left, and limbic left. These preferences result in a profile of a student who is practical, works with known facts, and is best at solving problems the best. Organizing, analyzing, planning, and integrating are also among the work tasks done best. Decision making is generally based on an impersonal analysis influenced by a strong left brain preference for solving problems in a rational, logical, or controlled manner. They are not likely to take high risks, and personal values rarely enter into decisions, and they seek rapid agreement on goals so that they can structure time to assure progress will be made toward achieving the goal. There is a low preference for functions attributed to the right brain. Thus. the forest may not be seen through the trees (although 11% say that they are best described by the word holistic), or emotional or interpersonal aspects of work may not receive emphasis. For example, interpersonal relationships on the job are generally based on technical aspects and competence rather than personal warmth and feeling.

INTRODUCTION

The twenty week Program Management Course (PMC) is the premier course of the Defense Systems Management College (DSMC). It prepares mid-level managers for increased functional management and defense system acquisition program responsibilities. Emphasis is placed on teaching functional knowledge and integrating it through five and six person learning teams and group problem solving. Students who attend PMC have well established careers in the military, government, or the defense industry. Most have proven to be high achievers over their 38 year average age.

This paper briefly explores the concepts behind Ned Herrmann's Participant Survey Form which provides a brain dominance metaphor, and the Myers-Briggs Type Indicator (MBTI) which provides a psychological type report based on the work of Isabel Myers, Katherine Briggs, and Carl Jung. PMC students take both of these instruments. Individual and aggregate data from the instruments provides insights into the characteristics of people who are involved in an acquisition management career.

The academic setting provides an opportunity to explore individual differences and how these differences can be combined to form a high performance team and organization. This is important since managers must be able to channel individual contributions toward organizational goals. When used for self development, the student can discern how his or her preferences impact future job assignments. Feedback on the theory, results, and application of these instruments is used to increase the student's self awareness, to provide a frame of reference for assessing the characteristics of other people, and to apply the theory behind each instrument to explore how individual differences affect how people work together.

Also, the models presented by both instruments often provide new insights on why organizations do not run as effectively as one might desire. Many occupations are selected by people with similar preferences, but people with different preferences frequently work together especially in acquisition management. Understanding and recognizing these differences is essential if organizational problems are to be minimized.

Student data suggests that the acquisition community is relatively homogeneous based on these two models (left brain and sensing-thinking types). However, there are differences within these categories, and there are those acquisition personnel who appear to march to the beat of a different drum due to preferences which deviate from the community norm. Both instruments have been used successfully in consultations with acquisition organizations.

Individual differences can be a barrier to achieving high performance. For a group to work well together, team members must actively work to understand where each member is coming from, and work to enhance team task and maintenance functions. Efforts must be made between individuals in different work teams to keep open clear communication's channels. As examples, individuals or work teams may have a narrow focus on their organization's purpose based on their profession; they may feel uncomfortable working with people who are different; or priorities and organization direction may not be clearly communicated because leaders assume all people in the organization are seeking the same goals.

The sections which follow briefly describe both instruments, and the characteristics of the primary groupings in which PMC students tend to fall, and some relationships which have been identified between the two instruments. Assuming that PMC students are representative of the defense systems acquisition management community, the descriptions should provide awareness of the characteristics of that community.

OUR BRAIN:

There has been much speculation of how brain functioning relates to how well people perform in their occupations. As the interest in the nature and workings of the human brain spreads, and new technologies are developed to analyze the brain, great strides are being made in answering concerns of this nature. Researchers have been busy seeking an answer. However, there is still much that we do not know.

Our brains contain billions of neurons. Each acts like a personal computer with thousands of input and output "cables" connected to other neurons. Communication between neurons is controlled by an electrochemical process, and transmissions between the left and right brain hemisphere flow through the corpus callosum, a bundle of over two million nerve fibers which may be thought of as a telephone switchboard.

Frontal lobotomies were popular during the 1940's and 50's. New drugs replaced this procedure, but not before 40,000 people underwent surgery in the United States. Relatives of these patients noted the individual became tactless, careless, and incapable of holding back after the operation. Their IQ, memory, and ability to understand abstraction remained intact.[1]

The Russian neuropsychologist, Alexander Luria, tested several hundred people who suffered frontal lobe brain damage. He found that the frontal lobes were crucial for a person to be able to look ahead in their life, to plan, and to set goals and work toward there achievement. While they could perform most simple tasks such as writing, speaking, moving their body, and recalling information that had been previously learned, they had difficulty thinking of fresh ideas.

In the 1960's, Roger W. Sperry, the 1981 Nobel Prize winner, and his colleague, Michael S. Gazzaniga, explored the functioning of patients who had undergone an operation severing the corpus callosum. This operation was done to restrict epileptic seizures to one hemisphere of the brain. They discovered that when the brain is bisected at the corpus, there are two separate memory systems, and competition for control. The "split brain" subjects functioned with two separate minds. His work made it apparent that a large number of human activities are probably regulated by specialized areas of the brain.

It may be surmised that the frontal lobes operate like a manager since they act to decide which information should be used, and how it should be used. They manage the electrochemical impulses which trigger right brain neurons to provide holistic and intuitive insights on the problem, and left brain neurons to sequentially process rational, logical, or mathematical information. Research seems to suggest that the frontal lobes also control our self awareness and initiative, in addition to our ability to plan. Then, there are the parietal lobes which provide motor control, sensory responses, and complex intellectual functioning. The temporal lobes appear to control speech, memory, behavior, emotion, and the auditory pathways.

For normal people, there is an interplay between the two hemispheres. This suggests that hemispheric competition (often resulting in a dominant preference) is a normal human condition. Recent EEG (electroencephalograph) measurements of brain wave activity indicate that the hemispheres trade off domination. Periods of domination range from

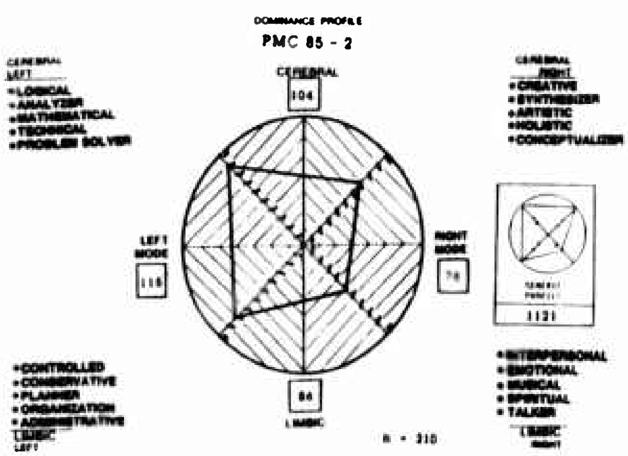
25 minutes to 200 minutes. The average is two hours.[2] However, it appears that synchrony, a condition in which both hemispheres are acting in unison, may be the most beneficial state for thinking and using the brain.

HERRMANN PARTICIPANT SURVEY:

DSMC uses the Herrmann Participant Survey, a 120 item instrument which provides feedback on an individual's brain dominance preferences. Herrmann's instrument is divided into eleven sections, and solicits information on education, occupation, handedness, work elements done best, key self descriptors, hobbies, adjective pair preferences, introversion/extroversion, energy level, motion sickness, and agreement or disagreement with twenty statements. The brain functioning metaphor was developed by Ned Herrmann while he was a senior manager with the General Electric Corporation.

Feedback is provided on a person's preference for using the cerebral and limbic modes of the left and right hemisphere. Students receive preference scores for the four quadrants (cerebral left, limbic left, limbic right, and cerebral right), left brain, right brain cerebral, limbic, and a generic profile. Figure 1 below is representative of the pictorial feedback received by students. The numbers which have been used are the average scores for PMC class 85-2. Five adjectives are used to describe the major attributes of each of the quadrants.

Figure 1




What are some of the occupations we find in each of these quadrants? People with a cerebral left preference are often engineers, mathematicians, operations researchers, lawyers, and medical doctors. Planners, bookkeepers, administrators, law enforcement personnel, and military personnel have limbic left preferences. In the limbic right, clergy, social workers, nurses, teachers, and musicians are most often found. Finally, the cerebral right is the dominant preference of artists, trainers, entrepreneurs, and chief executive officers. All of these occupations are strongly associated with one quadrant of Herrmann's "Brain Dominance Profile". Most occupations have preferences in more than one quadrant of the model.

The key descriptor section probably gives the best profile of PMC students. In this section, the individual completing the instrument is asked to select the eight adjectives which best describe "...the way you see yourself." They are then asked to select the one adjective which best describes them. Being rational was at the top of the list with 18 percent selecting it. Next was logical at 12 percent. At the bottom of the list was verbal with one individual selecting it as the adjective which was most descriptive. Table 1 presents the percentage of students (n = 210) in PMC class 85-2 selecting each adjective as one of their eight choices.

Table 1

KEY DESCRIPTORS FOR PMC 85-2

| | |
|---|---|
| LOGICAL - 76% | RATIONAL - 71% |
| CONTROLLED - 52% | ANALYTICAL - 50% |
| CONSERVATIVE - 49% | FACTUAL - 43% |
| HOLISTIC - 40% | INTUITIVE - 39% |
| CRITICAL - 37% | DETAILED - 36% |
| QUANTATIVE - 33% | CREATIVE - 31% |
| DOMINANT - 29% | MATHEMATICAL - 27% |
| SYNTHESIZER - 25% | READER - 25% |
| VERBAL - 24% | EMOTIONAL - 21% |
| SEQUENTIAL - 19% | SIMULTANEOUS - 16% |
| SPIRITUAL - 14% | SPATIAL - 12% |
| ARTISTIC - 9% | SYMBOLIC - 8% |
| MUSICAL - 6% | |

The Herrmann Participant Survey asks the individual to rank the work that they do best. Over 30 percent of the students said that they are best at problem solving, organizing, analysis, or planning. Less than fifteen percent said that they were best at the financial, innovative or creative aspects of their work.

Fifty-eight percent of the students fall into four of Ned's generic patterns which are based on assigning the number 1, 2 or 3 to the scaled score for each quadrant. Scores greater than 67 are given a 1 which indicates the person has a primary dominance in that quadrant. Approximately one-third of the PMC students have a 1122 left brain profile. A "whole brained" person would have a 1111 profile.

The class profile shown in Figure 1 depicts a triple dominance. The limbic right quadrant reflects a secondary dominance based on the scoring which assigns a 2 to scaled scores between 34 and 67. (A scaled score below 34 is given a 3, and reflects the least preferred mode.) Since these are preferences, a person who has a three in a quadrant may avoid or procrastinate doing work or activities associated with that quadrant. Many people can do superb work which requires them to use a quadrant they have a 3 in their profile. Some students have hobbies which are associated with this least preferred mode. This helps to provide balance.

As a manager or peer, it is useful to know individual preferences. With such knowledge, assignments can be made which will excite the individual and build on his or her preferences. Organizationally, work teams, tiger teams, or committees might be formed with people who represent strong preferences in all four quadrants.

Quadrant preferences are shown in Table 2. The left brain preference stands out with 81 percent having their highest score in the two left quadrants. The left brain preference is further reinforced by over three-fourths of the students having a strong preference (67 or more) for the two left brain quadrants. Perhaps these preferences are so strong because Western culture has valued verbal ability, and logic.

Table 2

QUADRANT RELATIONSHIPS

| Quadrant | Percentage: Highest Quadrant Score | Percentage: Generic 1 in Quadrant |
|---|---|---|
| Cerebral left | 54 | 76 |
| Limbic left | 27 | 76 |
| Cerebral right | 2 | 17 |
| Limbic right | 17 | 36 |

For effective communications, it is important to recognize that individual preferences may create barriers, or make it appear that a person is not adaptable. For example, people with strong cerebral left preferences work with facts, are rational, and are oriented toward high technology. On the other hand, people with strong limbic left preferences would limit their exposure to risk, set up control systems, develop detailed plans, and are well organized. What would be the consequences if the two had to work together? Yes, we have all seen examples of engineers who do not follow detailed administrative procedures which result in paperwork that does not appear to contribute to mission effectiveness, and of managers who are not willing to develop detailed plans because they say that they know what they want to achieve.

What happens when a person with a strong left brain preference has to deal with a person who has a strong right brain preference? Quite often, the "left brainer" sees a visionary who does not have his or her feet on the ground, who takes excessive risks, is very loose in their management or personal style, or who spends too much time socializing on the job. The "left brained" person would be very surprised to see a proposal which is delivered on or before the due date by the "right brained" person.

Research finds that the percentage of leaders and managers with right brain preferences increases as one moves up the organizational ladder. Thus, a "right brained" leader might find a "left brained" manager to be structured, spends and excessive amount of time on details, and not very responsive to suggestions related to the big picture.

PSYCHOLOGICAL TYPE:

Student's complete the Myers-Briggs Type Indicator (MBTI), a psychological instrument based on Jungian typology. Feedback is provided on four bipolar scales. The scales are based on how we use our psychic energy to deal with the environment; how we gather information; how we make decisions with the information we have gathered; and how we relate to our environment in terms of control versus adaptation. A brief description of each follows.

E - EXTRAVERSION -- a person who generally relates with more ease to the outer world of people and things
OR
I - INTROVERSION -- a person who generally relates more easily to the inner world of ideas

S - SENSING -- a person who generally prefers to work with known facts
OR
I - INTUITION -- a person who generally prefers to look for possibilities and relationships

T - THINKING -- a person who generally prefers to base his or her judgments more on impersonal analysis and logic
OR
F - FEELING -- a person who generally prefers to base his or her judgments on personal values

J - JUDGING -- a person who generally likes a planned, decided, and orderly way of life
OR
P - PERCEIVING -- a person who generally likes a flexible, spontaneous way of life

These four scales result in 16 possible letter combinations. As shown in Table 3, over 66% of the DSMC students attending the twenty week Program Management Course fall into the four types at the corners. (A random sample of the United States population would find 26% in these four types. Most organizations draw their leaders and managers from these four types.)

Table 3

DSMC TYPE TABLE

| | | | |
|---|---|---|---|
| ISTJ = 28% | ISFJ = 3% | INFJ = 1% | INTJ = 11% |
| ISTP = 6% | ISFP = 1% | INFP = 1% | INTP = 6% |
| ESTP = 4% | ESFP = 1% | ENFP = 2% | ENTP = 5% |
| ESTJ = 18% | ESFJ = 2% | ENFJ = 1% | ENTJ = 9% |

n = 1383, drawn from PMC classes between 7/86 and 8/88

In the acquisition business, the majority of people combine sensing (S) and thinking (T). Sensors generally like to solve immediate problems, pattern their actions on what has worked before or based on what others are doing, and they don't like to fix things which are not broken. They also want practical, down to earth goals, and they will zero in on details to clarify the goal setting process. The thinking preference results in the task being more important than relationships, ideas are presented logically with plenty of back-up evidence, errors and inconsistencies are pointed out, and conflict may drag on. The T will strive for an objective and concise goal.

Extraverted (E) leaders need to be aware that they often do their thinking out loud. As a result, subordinates can take this thinking as a firm decision or direct order. Extraverts also need to learn that introverts (I) like to have meetings which are announced in advance, and have an agenda. This is so the I can come prepared.

When an intuitor (N) works with a sensor (S), the N needs to do homework so that there is an explicit statement of the problem, and a plan of action. The S wants facts, not possibilities. Judgers (J) need to be mindful that perceivers (P) may not need an immediate decision, and that the P may not have a strong need for deadlines. In goal setting, the J wants to agree on the goal as fast as possible in order to begin working toward achieving the goal. The P may cause heartburn because he or she sees something new and seeks to redefine the goal.

By combining the two middle letters which reflect mental functions, an awareness can be gained as to how a person might handle his or her job. ST types are practical and matter-of-fact. They like to use their technical skills with facts and objects in areas such as business, production, and applied science. On the other hand, NT types are logical and ingenious. They like to use their abilities for theoretical and technical developments, and are most likely found in research, the physical sciences, management, and analytical work.

In contrast, there is the people orientation of the SFs and NFs. The SF is sympathetic and friendly, and likes to be helpful and provide services to people. SFs are found in patient care, teaching, sales, and community service. Intuition makes the NF enthusiastic and insightful. NFs like to use their ability to understand and communicate with people, and are found in the behavioral sciences, research, and teaching.

Over half of the students fall into the SJ temperament group. These people always know who is in charge or will take charge, they are excellent administrators especially in organizations which require precision, they have procedures for everything, and they are dependable.

The 31 percent who fall into the NT temperament group have as their greatest strength the ability to see the big picture. These people are the strategic planners and researchers, and they frequently learn by challenging authority or established principles. They gather abstract data and are aware of the possibilities as they go through an objective decision process.

Twelve percent have an SP temperament. These people make excellent trouble shooters and negotiators. If they are a manager, they probably have the ability to solve problems which appear as a major crisis to others in the organization. They like a hand-on approach, and have a sense of immediacy in the work they have undertaken.

Five percent of the students fall into the NF temperament. They are the idealists who work to advance human interests. To them, a key value is to be in harmony with themselves and with others. This is reflected in a desire to help others, and draw out the best in people.

Another combination of the letters can be used to predict individual or organizational tendencies. The IS people will want to retain the status quo; the IN people will want to look at problems and operations from several different vantage points; the ES people will want to jump right in and lead the charge to get the job done; and the EN people will want to make changes. By recognizing individual preferences, it may be possible to minimize conflicts which are caused by a lack of understanding of where a person with a different type might be coming from.

## COMPARING HERRMANN AND THE MBTI:

Table 4 presents the relationships between the Myers-Briggs types and PMC student responses to Herrmann's key descriptors.

Table 4

KEY DESCRIPTORS BY TYPE

| Type | Key Descriptors |
|---|---|
| ISTJ | Rational, Quantative, Factual, Logical, Detailed, Controlled |
| ISTP | Rational, Factual, Intuitive, Conservative, Controlled |
| ESTP | Rational, Holistic, intuitive, Dominate |
| ESTJ | Dominate, Rational, Factual, Conservative |
| INTJ | Holistic, Intuitive, Logical, Creative, Controlled |
| INTP | Critical, Holistic, Intuitive, Logical |
| ENTP | Rational, Holistic, Intuitive, Logical, Verbal |
| ENTJ | Intuitive, Analytical, Dominate |
| NF | Artistic |
| ST | Rational |
| SJ | Factual |
| F | Emotional |

## CONCLUSION:

Students who attend the Program Management Course represent a cross section of the acquisition community. They are practical individuals who work with known facts to set goals and solve problems. Organizing, analyzing, planning, and integrating are also among the work tasks done best. An impersonal analysis influenced by a strong left brain preference for solving problems in a rational, logical, or controlled manner is used for making decisions. They are not likely to take high risks, and personal values rarely enter into decisions. Interpersonal relationships on the job are generally based on technical aspects and competence rather than personal warmth and feeling.

Being aware of psychological type, and brain dominance has everything to do with management. Individual preferences directly relate to the way a person goes about accomplishing his or her job. Knowing these characteristics can enable program managers to use and develop their people more effectively.

FOOTNOTES:

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COMPETITIVE CONTRACTING OFFICES:
AN ALTERNATIVE TO A SEPARATE ACQUISITION CORPS

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## ABSTRACT

Competing contracting services between government contracting offices would improve customer satisfaction by improving contracting timeliness and quality, advance professionalism, increase employee satisfaction and retention, reward the most productive contracting teams, and reduce overall cost.

The Department of Defense (DoD) uses a bureaucratic form of organization and provides for contracting support along organizational, geographic, or product speciality lines. Excessive regulation and burdensome oversight have caused contract specialists to hide behind the regulatory cloak, leading to less professionalism and more dissatisfied customers. Allegations that the system is out of control have brought forth suggestions that fundamental change is needed. One proposed alternative is a single, civilian centralized acquisition corps. But that approach would retain the bureaucracy while creating a monopolistic organization as inefficient in allocating resources and providing high-quality contracting services as monopolies are in the private sector.

We suggest another alternative, an organization combining the advantages of the free marketplace with the essential controls needed to preserve the public trust. We propose a competitive contracting office (CCO) concept under which customers select the contracting office that best meets their needs, price and other factors considered. Under our proposed organization, the directors of CCOs will have discretion over prices charged for contracting services provided and reduced constraints on the uses of the revenues received. One manager might provide more costly but faster service and pay employees bonuses for meeting agreed-upon goals; another might provide low-cost service meeting basic requirements. Managers would be held accountable for regulatory and legal compliance and rewarded on meeting financial goals and satisfying customers.

Customer satisfaction will be the primary goal of the CCOs. In addition, cost savings are typically achieved through the introduction of competition.

## INTRODUCTION

Customers believe that the contracting function is too slow and is unresponsive to their needs. Only half of the people on the acquisition team believe that contracts specialists provide adequate support [1]. Not only has this been the view of the immediate customer of the contracting activity – whether that customer be a major program office or a post, camp, or station – it has been the view of executive management, Congress, and the public.

One conclusion common to four decades of studies of defense acquisition is that the process needs to be better organized and the quality of the work force needs to be improved. Studies have recommended centralization of the process, with the objectives of increasing control; achieving greater efficiency; avoiding duplication and overlapping; and presenting a single, uniform, best method to accomplish all contracting. In recent months, this concept has even led to recommendations to establish a separate civilian acquisition corps [2]. While the objectives have merit, the concept conflicts with well-established theories of business and organizational efficiency.

For at least the last quarter century, there has been a desire to apply "business methods" to the acquisition processes of DoD.

> The single controlling theme of the [Packard Commission] was that the Pentagon should emulate the practices of private businesses to cut costs and increase efficiency [3].

One place where instituting business practices could be most usefully accomplished is in contracting. Providing incentives and creating competition are common practices to enhance customer satisfaction in industry. This can be done within a business by letting divisions compete and within government by allowing various organizational units to compete. Although the concept of competition is a central theme of procurement statutes, it is nearly universally ignored in the area of in-house provision of government services.

This paper explores the concept of applying commonly accepted business, economic, organizational, and management concepts to contracting services. We propose that customers be able to benefit by competition and select the contracting office best able to perform each contract action on the basis of a customer evaluation of technical capability, cost, and other factors. The concept builds on the assumption that effective competition

- Serves the needs of the customer
- Enhances performance efficiency and proficiency
- Reduces non-value-added work
- Contributes to total process improvement.

A major element in the proposed organization is the potential for enhanced leadership, the essential first step in motivating employees and encouraging professionalism. Highly motivated employees are the key to success in any labor-intensive operation. The proposed organization offers authority to employees able to accept responsibility and rewards their achievements. Successful managers and employees will be those who attract customers by providing superior service. The structure will help identify those few employees unable to meet their customer service responsibilities; they can be assigned to less demanding positions.

Further, our proposal provides for aligning authority with responsibility and permitting more effective contract support and enhanced employee motivation through the use of an innovative incentive reward system. A system embodying these features is one that will create the professionalism in the acquisition work force so frequently believed to be lacking today.

This paper will identify and develop the characteristics of a CCO and establish how such an organization will cure some of the many problems rather than merely treating symptoms.

## THE DILEMMA

### The Customer

Under the current system, customers are tied to a contracting office along organizational, geographic, or product specialty lines. Usually the customer cannot choose the contracting office to be used. This limitation effectively creates a monopoly of the contracting office. We learn early in Economics 101 that a monopoly will provide less output at a higher cost than would a competitive organization.

Because it is a monopoly, the dissatisfied customer has nowhere else to go and no control over resources. Under the current system, the service provided to the customer may be unrelated to the provision of resources to support the contracting office. In fact, there may be an inverse relationship: customer complaints about poor service bolster the contracting office's demands for increased funding, reducing the motivation for managerial effectiveness [4].

### The Bureaucracy

The primary form of organization in the federal government is that of a bureaucracy. The requirements for control in a large organization seem to fit the basic model and theory of bureaucracy, as set forth by many authors. One such description has been provided by Hellriegel and Slocum in *Management: Contingency Approaches* [5], summarized below.

Seven characteristics are recognized as central to a bureaucracy's definition: *rules and regulations* determine the employees' decision-making behavior. This uniformity and order provides the stable base for the organization. Using those rules and regulations leads to *impersonality*, which protects objectivity. Thus, individuals within the organization are protected from the personal whims of superiors. Since each job is narrowly defined, the bureaucratic organization can take advantage of each person's skills through *specialization*. The *hierarchical structure* provides increased power and authority for superiors. The bureaucratic system is essentially autocratic.

Managers treat employment in the classical bureaucracy as a *lifetime career* commitment. Devoted performance of duties will be promoted by job security, tenure, incremental salaries, and pensions. Authority within the organization is based on the *legal authority* of the rules and regulations accepted by members of the organization, and communication flows vertically. The organization is based on the *rationality* of logic and science. All activities are directed to organizational goals.

### The Problems of the Bureaucratic Approach

Many of the above characteristics suggest the benefits of a bureaucracy. However, they may lead to negative effects as well. Some frequent criticisms of the inefficiencies of bureaucracy are [6]

Excessive red tape created by complicated and often obsolete rules and regulations
The "run-around" when jurisdictions are confused
Buck-passing because of failure to delegate decision making far enough down the line
Indifference and abruptness to customers seeking explanations, because of low employee motivation and a feeling of security in a situation devoid of challenges
Delay in decision making when channels of communication are over-extended through many echelons of authority
Encroachment of staff services on the unified command of the line organization because responsibilities have not been clearly determined
Lack of sales motive when competition is restricted
Inflexibility caused by a martinet insistence on perfection
Timidity due to an urge to play it safe
Officiousness because of low morale or uncompensated ego desires

- Mediocrity resulting from a belief that leveling is the best policy
- Waste and carelessness due to lack of employee interest
- Featherbedding encouraged by a feeling of insecurity or a sense of real or imagined injustice
- Conformity for fear of being considered ambitious, overaggressive, and a threat to the group norm
- Secrecy emphasized for the feeling of power it offers to the group or the individual
- Group resistance and heel-dragging following feigned acquiescence, because of a desire to keep to the old ways of doing things

In spite of the potential drawbacks mentioned above, bureaucracies continue to have merit in certain situations. As noted by one author

> For the production of a standardized product or service on time, day-in and day-out, throughout the years, the bureaucratic form of organization cannot be surpassed. Its effectiveness for this kind of mission is high [7].

But today's contracting is often not characterized by the production of a standardized service. the contracting environment is a varied and complex one with a myriad of laws, regulations, and business complexities. Despite the rules and regulations that abound, the importance of making prudent business judgments has never been greater. Contracting personnel have mixed responsibilities and are expected to be diversified business experts. Lifetime careers are no longer the rule, given the tendency toward social change, increased transportability of skills, and widespread desire to leave government for better positions in industry. No longer can government afford to maintain unproductive employees simply because they are devoted – effectiveness, leadership, and the accomplishment of specified objectives are now central.

An alternative management and organizational approach to contracting services is necessary to make progress in correcting acquisition problems, as opposed to simply treating symptoms, as has been done for many years.

### Breaking the Vicious Cycle

While moving away from the bureaucratic form of organization to a more adaptive system is necessary, any change will be hampered by the vicious cycle that exists of more and more oversight resulting in less and less professionalism. Excessive management controls and oversight, less-than-professional treatment, and bureaucratic frustration have resulted in many good people leaving government. More than half of DoD contract specialists would leave if offered jobs in other federal agencies or in private industry [8]. This exodus is creating a "brain drain" of the acquisition talent inventory, leaving the few remaining talented professionals to compensate for the less motivated, undereducated, and inexperienced. A more rewarding and better work environment must be developed to alleviate these negative effects. The result will be more efficient and effective acquisition.

Management controls are necessary to assure the public trust. On the other hand, excessive bureaucratic controls are expensive and wasteful, and they adversely affect the motivation of the contracting professionals. Today's political environment has generated extreme amounts of direct and indirect controls and external influence. Some examples are

- Increased leverage by audit agencies, undermining the contracting officer's authority
- More inspector general clout (and resources), justified by more audits, allegations of fraud, etc.
- Greater congressional oversight, which, while well meaning, is disruptive and is often characterized as micromanagement
- Increased amounts of critical press coverage by a highly competitive press corps pursuing allegations of fraud impacts morale and inhibits risk taking
- Additional activity of competition advocates, who are evaluated primarily by agency competitive procurement rates, sometimes resulting in competition for competition's sake
- Countless other pressures, including those created by legal counsel, breakout advocates, small business advocates, and minority advocates, none of whom are ultimately responsible for accomplishing the procurement.

These external forces are in addition to, and in some cases duplicative of, well-established internal management controls. Their combined effect frequently lengthens the critical path of contracting. Under these extreme oversight conditions, educated and highly motivated professionals are required now more than ever to implement our growing body of complex laws and regulations.

Secretary of Defense Dick Cheney, according to his recent report to the President [9], plans to establish a task force to review existing programs and initiatives for "advocacy" or special, single-purpose requirements placed on program offices, with the objective of eliminating as many of these advocacy programs as possible. Clearly, the influence of "advocates" is not limited to program offices; they have a significant impact on the contracting function as well. Their individual and oftentimes conflicting motivations must be balanced by the acquisition professional, who is ultimately responsible for implementing laws and regulations.

As aptly stated by the American Bar Association (ABA):

> One ultimate effect of more oversight and more laws is to make contracting officers less efficient in their work and more focused on contracting as an administrative process than on the ultimate purpose of filling the procurement needs of the agency .... they are afraid to express ideas and afraid to act beyond their familiar

> routines. Contracting actions become mechanical; imagination, judgment and common sense dry up. In the opinion of the Committee this is one of the most inefficient and costly aspects of the DoD acquisition process [10].

To correct this problem, the ABA report recommends:

> Congress should be less impelled to direct the specifics of how contracting officers are to do their jobs and less inclined to demand the volume of reviews, reports, and other controls which today inhibit the exercise of sound business judgment [11].

While Congress is not the direct cause of all of the impediments to achieving a motivated, customer-oriented work force, the congressional push for more and more oversight inevitably saps initiative and develops a self-protective attitude in the work force. This vicious cycle of additional oversight and less professionalism must be stopped, and could be substantially curtailed with our new proposed organization.

## CONCLUSIONS AND PROPOSAL

Organizations and people respond to the hand that feeds them. Under the current system, resources are generally provided by some office higher in the bureaucratic chain rather than by the customer. Contracting organizations' resources are limited by superiors, so that the contracting office's true constituency becomes the higher levels in the chain. Since the superior organization's goals may conflict with the customer's goals, the customer may well be unsatisfied. Program managers and other customers, including the general public, are frequently dissatisfied with contracting services. They want high-quality and responsive services, and they are unlikely to get them under existing organizational patterns.

Currently, contracting organizations are tied to customers or products. It is generally not possible for a customer to select the procurement organization to perform contracting services. Customers must go to a prescribed organization, making that organization a monopoly with respect to that customer. Higher quality, lower cost, and more timely service result from a competitive environment, not from a monopolistic one. Competition requires minimizing expenses, and since unnecessary layering is expensive and time consuming, it will be eliminated. Since service organizations have low capital requirements and reach economies of scale at relatively low levels, it is not prohibitively expensive to introduce competition in the provision of contracting services.

We propose a CCO concept, under which customers select the contracting office for their procurement that best meets their needs, price and other factors considered. The CCO is envisioned to be a self-contained contracting office, including legal counsel, divided into business segments that will perform all contracting functions desired by the customer.

DoD activities having a need for procurement support services should have wide latitude in selecting the office to perform the service. In turn, CCOs should have wide latitude in establishing the services to be provided while still maintaining compliance with laws, regulations, and sound business practices. In advance of each individual contract action, the customer and the contracting office should agree on the level of service to be provided and the price for that level of service.

Contracting offices will be more responsive to customers who provide resources, since these offices will be held accountable to those customers. Customer control of resources, coupled with a competitive atmosphere, will improve the quality of services. The price mechanism will work throughout the contracting office, just as it does now in the private sector, to provide resource allocation information. Offices and sections of offices that are viewed by the customers as returning good value for the money spent will receive more business and, thus, more funding than those perceived as providing low value. CCOs may be funded as industrial activities are now, or by using some similar method. Competing contracting services will improve quality, cost, and timeliness.

## SUPPORTING CONCEPTS

Many related concepts support our proposal. We have included here a discussion of the commercial marketplace, the organic system, and Total Quality Management (TQM) to illustrate that they are mutually supportive of CCOs. This review shows homogeneity of their respective objectives and potential benefits.

### The Commercial Marketplace

The commercial market keeps responding to changing business requirements to better serve its customers. Changes currently being made follow the concept and approach proposed here. Within the past few months, for example, a major management change was made by Sears, Roebuck & Co. to be "more creative, responsive, efficient and accountable [12]." Generally, successful managers are problem solvers, innovators, motivators, and creative team players; thus ". . . teams that are most effective are those most open to new ideas, wherever they come from [13]."

*Business Week* has recently featured two cover stories that discuss and support those same concepts. According to the first, concerning whether companies were too big, "One corporate Goliath after another is trying to act like the Davids of the business world, creating smaller, highly decentralized business units and giving managers greater flexibility and freedom with less staff review [14]." In the other, on the payoff from teamwork, it was reported that teams of 5 to 15 persons, producing an entire product, can increase productivity 30 percent or more and substantially raise quality. Flatter organizations result as supervisory layers are eliminated [15].

### The Organic System

A newer model of organization has been termed the organic or organic-adaptive system. Organic systems adapt to changing conditions. Job definitions are continually altered by interaction with others as the task progresses. Interaction is both lateral and vertical. "More information and consideration enter into decisions, the limits of feasible action are set more widely [16]." The current contracting environment is best characterized as one of changing tasks and a thrust toward streamlining which requires adopting management practices and philosophies consistent with the organic system. Features of such a system are listed in the table below [17].

**COMPARISON OF ORGANIC AND BUREAUCRATIC MODELS**

| | Organic | Bureaucratic |
|---|---|---|
| Job definition | Shifts over time<br>Self-controlled staff | Rigid, narrow<br>Conformity to rules |
| Employee commitment | Shared beliefs about organizational values and goals | Goals set from above |
| Authority | Delegated and dispersed | Autocratic, by position |
| Organizational communication | Horizontal, diagonal, vertical advice and information | Vertical, closely held<br>Direct orders |
| Team concept | Collaboration and consultation<br>Sharing authority and responsibility | Manager makes all decisions and announcements |
| Span of control | Wider span, flat organization | "Tall" organization, layering |
| Employee participation | Members take on solving problems | Pass the buck, avoid responsibility |

We believe that the organization of the contracting function set forth in our proposal will much more closely resemble an organic system and allow a departure from the bureaucratic form of organization.

While job definition is quite narrow in many functions of government, contracting requires judgment, leadership, and human skills that cannot easily be quantified. The Federal Acquisition Regulation (FAR) notes that "contracting officers should be allowed wide latitude to exercise business judgment [18]." In selecting individuals as contracting officers, the appointing official shall consider "the candidate's experience, training, education, business acumen, judgment, character, and reputation [19]." A wide range of talents is necessary to permit the contracting officer to adapt to the changing contracting environment.

The CCO's teams will share the agreed-upon goals established with the customers. A more collaborative spirit will develop, alleviating the complaint often made by the customers that contracting personnel are not mission-oriented and hide behind the "regulatory cloak." In addition, the envisioned CCO will provide incentive rewards that will further motivate employees to participate in problem solving to meet common goals.

Authority to contract is a delegated function flowing from the agency head to those with specialized knowledge and experience. The contracting officer's authority is established in part by the warrant provided by the agency and in part by the knowledge, expertise, and overall usefulness he or she provides to the customer. In the CCO, each team will negotiate agreements with its customers and will have the authority to carry out its responsibilities. With these teams having sufficient authority and accountability, a broad span of control is possible.

Communication is central because the teams must draw upon the expertise of audit, legal, engineering, transportation, and other personnel to comply with the incredibly complex regulatory system. CCO collaborative teams sharing authority and responsibility to meet agreed-upon goals will be encourage to find the most effective means to communicate, obtaining advice and information from all directions.

The CCO concept can serve the interests of the customer because it adopts practices and management philosophies that are consistent with the organic environment in which it is operating.

### Total Quality Management

TQM is both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. It centers around customer satisfaction, employee involvement, and process improvement. Because TQM can be applied to all processes, and since contracting is a process, CCOs can benefit from this concept. We have applied TQM key features to the contracting function operating in our proposed organization. A strong relationship between these two separate but similarly derived concepts is apparent.

Under the proposed organization, participatory management styles and teamwork would be more heavily rewarded. Specifically, financial rewards for teams would be a function of efficiency, not size. Accomplishing schedules, achieving budget, and effective resolution of disputes and protests would be encouraged and rewarded. Having a relatively "flat" organization with reduced levels of management facilitates employee involvement in improving the contracting process by using the TQM philosophy. In doing so, it also achieves other important DoD initiatives, e.g., streamlining, aligning responsibility with authority, and reducing budget and management layering.

Regarding customer satisfaction, it is easy to lose sight of who the customer is within a contracting organization when the customer does not provide the resources. Contract specialists currently respond to pressures and requirements of line management, Congress, the Inspector General, program managers, budgeteers, auditors, and various advocates who have been growing in number and power.

Under our proposed organizational concept, there would be no confusion regarding who the customer is and how the scales must tip in balancing the many conflicting objectives of contracting for that customer's needs. The difference, in large part, will be that management will be able to attract and retain the caliber of contracting professionals necessary to make and justify the many difficult judgmental decisions required. These professionals will be motivated to take the necessary risks.

Management's commitment to continuous process improvement is the essence of TQM. Many job positions are now classified by complexity and number of employees supervised. But growth of staffs is usually brought about by inefficiency and overregulation not in the customer's best interest.

In our proposed CCO, teams will be motivated by both financial and nonfinancial rewards (e.g., less management audit) to find innovative ways to be better, faster, and cheaper. Implied here is the notion of doing more with fewer people. Rewards will be based on meeting budgets and providing customer satisfaction (leadtimes, protest resolution, and effective contract administration).

Regarding employee involvement, TQM requires a cultural change to refocus the role of management and capitalize on employees' ideas for improvement. In the present system, efficiency goes unrewarded. A supervisor who is efficient and requires fewer resources (e.g., personnel) loses employees, who in part are the basis for classifying his position at a particular grade. There exists, as a result, a motivation toward inefficiency to maintain or enlarge an organization. In a CCO, however, employees will be motivated to find ways to become more efficient to maintain or increase their business base. Managers and employees will be rewarded for their involvement toward this end.

TQM is an emerging philosophy within DoD. CCOs provide fertile ground for implementing its concepts. CCO managers should be trained in TQM and its techniques to implement continuous process improvement.

## IMPLEMENTATION

### Internal Control

Instituting a major organizational change without also designing management controls appropriate to the new organization would only continue the historical patchwork approach to correcting contracting problems. However, even in the current environment, progress could be made if excessive oversight could be pared away in exchange for new and innovative internal controls specifically designed to enhance professionalism and organizational efficiency within CCOs. Therefore, the CCO proposed here also includes alternative management controls.

There is little dispute that current acquisition controls are excessive, although many disagree on what to do about the problem. In general, the design of internal controls should be based on risk analysis and cost/benefit analysis, with an aim toward ensuring that the public trust is being fulfilled. Also important to management control design is providing for a checks-and-balances review to assure integrity in the contracting process. We propose that a procurement management review (PMR) team visit each procurement office periodically for accreditation purposes. We suggest that accreditation may be established for various periods on the basis of the PMR team's assessment of the organization's ability to operate in compliance with laws, regulations, and good business practices during the accreditation period. The PMR team could also spread the word on successful performance to other CCOs. The PMR team should be independent and be comprised of contracts practitioners from other CCO offices on rotation to supplement core staff. This will enhance the objective that the PMR be focused on training and assistance in addition to internal controls.

In addition, we suggest a system of peer review within the CCO as a method of control that also provides cross training and additional experience. The peer review would operate much as a contract review board for individual procurements. However, the review team would be comprised of fellow contracting staff members and would be aimed at helping and at providing ideas rather than oversight.

The ultimate reward for successfully completing or passing PMR assessments is reduced oversight. A CCO that passes its first annual review may go 2 years before having another. Passing a 2-year review could permit the CCO to operate for a 3-year or even 5-year span before another review. Finally, another perquisite could be to permit a blanket waiver authority to the CCO director if the CCO were accredited for a specified period of time.

### Management Philosophy

The most effective managers will survive and thrive in a competitive environment. Management will have to implement changes to beat the competition. Unnecessary expenses, including those from redundant layering, will be reduced to meet the competition. Employee teams in pursuit of this objective will be effective and should be encouraged by gain-sharing incentives. As has been found elsewhere

> . . . alternative forms of compensation such as profit-sharing may foster higher productivity. . . . Employee participation may be one of the keys to higher productivity [20].

Individuals selected to manage CCOs should be leaders with participatory styles of supervision. They should be oriented toward motivating employees, enhancing organizational ownership and team cooperation, nurturing creativity, and structuring both financial and nonfinancial rewards to capture the essence of the mission – customer satisfaction.

Because these management capabilities are not ones that have been fostered within government contracting in the past, initial selection of the management team for the new CCOs must be done with care.

Employee Gain-Sharing

Rewards would probably be shared by all team members, including the typists, mailroom workers, lawyers, and others who worked on the contracting project, in addition to the primary negotiators and the contracting officer.

As noted from *Leadership for America: Rebuilding the Public Service* [21]

> OPM should continue past experiments witn "gain-sharing" in agencies. Such experiments allow agencies, employees, and the taxpayer to split the savings that accrue from higher performance and productivity. In continuing these experiments, labor and management must work together to develop a fair public test of this private-sector concept.

With such a charter, managers are limited only by their experience, knowledge, skill, imagination, and management fortitude.

Market Niche

We anticipate that CCOs will try to establish themselves in particular market niches just as service companies do in private industry. For example, one manager may attempt to fulfill the demand for very timely, responsive service. This may be provided by assigning a team to the customer that is more experienced, more highly skilled, and very enthusiastic and aggressive with regard to meeting agreed-upon goals. In return, this arrangement may cost the customer more than routine service would. The team may receive recognition and monetary rewards by achieving or bettering goals.

As an alternative, the contracting office might offer a discount service much like popular discount brokerages provide reduced services at lower costs. In this case, for a basic fee, contracting service could be provided much as it is currently. Staffing could be comprised primarily of trainees or others more suited to working under less pressure than that associated with the faster-paced special team described above. Assignment within the office would be based on the desires of the employee, as supported by demonstrated performance.

Further, additional services desired by the customer, such as consulting on acquisition strategy, requirements description, specifications review, and other contracting issues, could also be offered as desired. The desirability of the service, of course, will be demonstrated by the customer's willingness to pay for it.

Communication (marketing) from the CCO to prospective customers will be required. This will inform customers of the range of services that can be provided and help to train customers in what to look for in selecting an office to perform contract actions for them.

Legal and Civil Service Implications

Individual CCOs should have wide latitude in establishing procedures (within law and regulation) so that high levels of innovation will be forthcoming. This will include allowing individual managers to establish compensation plans and other working environment alternatives for their employees. Current laws permit implementing CCOs. Upon the agreement of agency heads, using alternative offices for provision of contracting services is currently authorized under 10 U.S.C. 2308 and 2390, 31 U.S.C. 1535, and 40 U.S.C. 481.

Our proposal can be accommodated within the current civil service system, by supervisors who are willing to use the full authority of the system. Monetary rewards can be established by application of Special Act and other awards on a contract project basis. Hiring and firing authorities that currently exist, along with the ability to transfer employees, also are adequate. Finally, job performance ratings may be much more meaningful, since they can be directly tied to the performance of the team in attaining the goals agreed upon with the customer.

While current law allows implementation of CCOs, their operation would be facilitated if the civil service system were changed to specifically accommodate CCO-type organizations. The Office of Procurement Policy (OFPP) Act [22] encourages the development of test programs for innovative procurement methods and procedures. Such test programs provide for waivers of inhibiting legislation, with certain congressional approvals.

Benefit of CCOs

In addition to the primary benefit of improving customer satisfaction, CCOs also provide for greater professionalism, increased employee satisfaction and retention, and a more responsive reward system.

While not the only objective, another important consideration is overall cost. When the volume of work is sufficient to support several providers at efficient economies of scale, there is little doubt that the competition will result in lower costs than a monopoly. Certainly in the provision of contracting services, with currently over 1,000 offices, there is a high volume of work, sufficient to support many CCOs. Over the years, many studies have attempted to determine how much can be saved by introducing competition into a formerly monopolistic situation. While the precise amount of savings cannot be determined, the change from a monopolistic, bureaucratic type of organization to one of open competition must result in significant savings.

## SUMMARY

DoD and the Services should start applying generally accepted economic and management theory to the provision of procurement services by allowing customers to choose the procurement office that best fulfills their needs.

Most Americans believe that the free-market structure of our business life is a substantial basis for the strength of this country. We applaud the efforts of the Chinese and Russians to adapt their bureaucratic economies to more closely resemble our free markets and believe that by doing so, they will reap the benefits of increased choices of better goods more efficiently produced. When free markets have not existed in the United States, we have taken action to outlaw such noncompetitive situations. Despite the clear depth of our belief that a free, competitive model is best, we have spent (and continue to spend) a great deal of time and energy in study after study tinkering with a bureaucratic system, trying to improve it. Our alternative simply applies all of our economic experience to use the power of a structure that works – free markets – vice the bureaucracy that doesn't work.

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# EVALUATING CHOICES IN HUMAN RESOURCE TERMS

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## ABSTRACT

The Department of Defense now requires that the services justify the manpower requirements at each milestone in the acquisition process for major systems. The services are expected to extend similar requirements to all systems. The acquisition and manpower communities must develop new approaches and tools to deal with the new requirements. To do this in a comprehensive fashion requires the development of common terminology and rules that will guide decisions.

This paper presents a theoretical structure which could form the basis for addressing the wide range of issues which will face manpower specialists, contractors and program managers, such as, assigning appropriate weights for trade-off analysis, providing a common terminology for discussion of manpower issues, examining the interaction of concerns in the several manpower areas, and developing policies that provide appropriate decision guidance. The paper will address human resources as a special public-policy issue and present criteria which would be appropriate for such issues. The criteria will be extended to the weapon acquisition process to develop illustrations of the decision hueristics that the acquisition and manpower communities must develop to accomplish the required integration of their concerns.

In order to address the human resource values involved, the paper will not consider other factors which must be taken into account in the actual acquisition process. It will assume that cost, schedule, and performance are held constant, and thus removed from consideration.

## INTRODUCTION

A major challenge faces the defense acquisition and human resource communities. Together, they must implement the Department of Defense response to Congressional concern over the relation between weapon technology and people. The Secretary of Defense is now required to submit to Congress a Manpower Estimate Report (1) prior to approval of full-scale engineering, development, production, or deployment, Milestones II and III, of a major defense acquisition program. The Manpower Estimate Report must account for all personnel needed to operate, maintain, support, or train for the system at full deployment.

The Department of Defense recognizes that the underlying problems giving rise to Congressional concern can only be addressed if the full scope of human resource issues is brought into consideration early and continuously in the acquisition process. The 1989 Defense Secretary's Report to the Congress (2) notes "...requirements for manpower resources must also be examined early enough in the acquisition cycle to ensure that proposed man-machine systems are structured in the most cost-effective manner possible." Early examination of the full scope of human resource implications is assured by the requirements of DoD and service policies beginning with DoD Directive 5000.-53.(3) This directive states: "This policy is intended to improve total system performance by improving all aspects of the human-machine interface. The policy, principles, and objectives of the Directive apply to all new "major" systems, "major" modifications of existing systems, and supporting training simulators and devices,..."

Contractors and the services must be prepared to demonstrate that their design and deployment decisions have been made with full consideration of the quantity and quality requirements for military, civilian and contractor personnel who will be involved in operating, maintaining, supporting, and training for the equipment. Providing an efficient and cost-effective fit of people as part of the overall weapon system will require program managers to examine system relationships from the perspectives of manpower, personnel, human factors engineering, training, safety, and health hazards prevention, generally referred to as MPTS. In implementing DoD Directive 5000.53, the military services are expected to apply the requirements not only to Category I programs, but to extend them also to Categories II, III, and IV. This means that MPTS concerns will affect program managers at every level and throughout the acquisition cycle. MPTS concerns will, in effect, be co-equal with cost, schedule, and performance as aims of effective program management.

The integration of human resource, or MPTS, issues in the acquisition process of weapon system design, development, production, and deployment is greatly complicated by the inherent non-quantifiable nature of many aspects of the problem. While we can quantify the life-cycle cost implications of a reduction in the size of the maintenance crew or the training reduction due to built-in automatic test equipment, we cannot easily quantify, for example, the effects of reducing the skills required to operate the equipment, or the gain from reducing operator stress.

For MPTS concerns to be fully integrated into the acquisition process, so as to be co-equal with cost, performance and schedule, program mangaers and contractors must have access to a set of MPTS guidelines for decision-making similar to those in the other areas. For example, in the area of cost, alternatives with lower discounted life-cycle costs are preferred to those with higher costs. Shorter production and deployment times are generally preferred to longer times. Alternatives which provide higher levels of performance are, likewise, preferred. The more difficult decisions, involving trade-offs among these characteristics, must still be made. But, at least, the decision maker has basic ground rules in each area to use as the starting point for such trade-off and cost-effectiveness decisions.

In the MPTS arena, such commonly accepted decision guidelines are not available. Without them, program managers cannot seriously consider and discuss cost--MPTS or MPTS- performance trade-off decisions. Analysis of MPTS concerns can be aided by the development of a structure which organizes the issues and approaches.

This paper presents a theoretical foundation for addressing a wide range of MPTS issues, such as, assigning appropriate weights for trade-off analysis, providing a terminology for discussion of MPTS issues, examining the interaction between concerns in the several MPTS areas, and developing policies that provide appropriate guidance for making decisions. This paper aims to start a dialogue on MPTS concerns by: 1. providing background information on the human resource aspects of public sector decisions; 2. developing a structure for analysis; and 3. illustrating some of the kinds of decision hueristics that must be developed to accomplish the required integration of MPTS concerns. Agreement on a basic structure will open the future possibility of analyzing MPTS in conjunction with other cost and benefit concerns.

## PUBLIC POLICY

In a democratic society, the government is accountable to the people for the resources it uses, the purposes for which they are used, and the manner in which they are used. The government has few resources of its own; most are granted to it by the people through voluntary gifts or through taxation. The use of resources for public purposes removes them from the private sector where they could be used to develop jobs or used for individual benefit and for future development of the national well-being. The government then becomes obligated not only to justify the need for public use of resources, but also to use the resources in the most efficient and effective manner possible. Although this is true of any resources, it is paramount in considering human resources. Here, government is accountable to its people for the use of those people.

Acceptance of the idea that a human resource perspective is important at every level of public affairs is founded on this view that the use of people for particular public purposes, such as the production of goods and services, entails an obligation to see that they are used wisely. This obligation is especially important for the military since, except in time of war, deterrence is the only benefit produced by the use of people in military service. Because of its non-productive character, the military must take special care to minimize its resource requirements. This applies to both money and real resources, particularly people Further, the resources should be used in a way that creates the least drain on society and is consistent with society's interest in those resources. To accomplish these aims, we need to examine military use of people from both resource allocation and human resource policy perspectives. The analytical structure provided in this paper draws on both of these areas of fundamental concern: public resource allocation theory and public human resource or manpower policy.

The public resource allocation perspective emphasizes that government must be accountable for its choices of the goods and services to be provided to the society. Having chosen to supply a particular service, government is also responsible for the effects on the society of the method chosen to provide that service, since different methods of providing the service will have different impacts on the society. These impacts need to be evaluated, not just in terms of cost as they have been in the past, but also in terms of their effects on the economy or society as a whole and its individual elements. The specific resource allocation effects are suggested by Musgrave (4) to be reflected in four primary facets - PRODUCTION, DISTRIBUTION, STABILIZATION, and GROWTH. These resource allocation facets then form one major dimension of an analytical structure for the MPTS/system integration problem. The other major dimension will stem from national human resource policy.

## MANPOWER OR HUMAN RESOURCE POLICY

One area of governmental interest in its people arises from the fact that people are the nation's most important productive resource through the contributions they may make as members of the labor force. As Mangum has noted (5), national manpower or human resource policy is concerned with:

1.) the availability of employment opportunities, which government affects by providing or subsidizing jobs and by control and stimulation of the economy;
2.) the development of people's capabilities, with an emphasis on the government's role in policy, direction, stimulation, and conduct of education and training; and
3.) the availability of personal income, which government affects by its influence on employment levels, by regulation, by taxation, and by the provision of transfer payments.

Moving down from the overall national policy level to the level of government operations, we can set aside the concern for personal income since it will be expressed in the wages and benefits the operating organization provides to its employees. Government operational units must, however, be concerned about the impact of their actions on developing the abilities of people and on the manner with which those abilities are employed. Many governmental actions have an impact on how people are developed and used, but we will focus on the design and deployment of military equipment as it affects the DEVELOPMENT OPPORTUNITIES and EMPLOYMENT or JOB OPPORTUNITIES of military and civilian personnel who are or might be associated with the weapon system.

Combining the manpower policy dimensions with the resource allocation facets results in a matrix of eight areas as shown in Figure 1. The following sections will develop the general and weapon-system-specific implications of each of the eight areas.

Figure 1
MATRIX OF HUMAN RESOURCE IMPACT AREAS

| PRIMARY RESOURCE ALLOCATION FACETS | HUMAN RESOURCE DIMENSIONS | |
|---|---|---|
| | JOB OPPORTUNITIES | DEVELOPMENT OPPORTUNITIES |
| PRODUCTION | | |
| DISTRIBUTION | | |
| STABILIZATION | | |
| GROWTH | | |

## THE PROPER USE OF HUMANS

The public resource allocation facets will be examined first from an overall public policy perspective. The sections below will define each of the facets and provide general criteria for evaluating public sector decisions. Later, we will draw on the perspective and general criteria to develop more specific implications for defense acquisition. The following material draws heavily on Musgrave's theory of public finance, since both public finance and human resource planning deal with fundamental questions of the impacts created when the government is involved in the acquisition and use of scarce resources.
The criteria presented below are based on constitutional principles, the American heritage, and traditional values. Such considerations as efficiency, equity, equal rights, freedom, justice, progress, equal opportunity, and fundamental human worth influence this search for decision guidance based on human values.

PRODUCTION - The production facet of manpower policy deals with the use of members of society to produce certain goods and services at public expense. Since this involves using human resources that could be otherwise utilized in the private sector or in other public sector functions, the focus here is on the efficiency of resource use and the conditions under which they are used. Public sector proposals then must be evaluated in terms of the manner in which they affect people and the need for the product or service which they produce.
Production Criteria: The proposed alternative should efficiently and humanely utilize people to provide an essential public good or service.

DISTRIBUTION - Under a democratic government, the public sector is held to a higher standard than the private sector. Full equity of treatment of its citizens requires that its decisions not impact unfairly on individuals or groups within the society. Any action taken should, insofar as possible, reflect a fair or just distribution of job and development opportunities across the affected individuals.
Distribution Criteria: The proposed alternative should assure that job and development opportunities are fairly distributed across the affected labor force.

STABILIZATION - Manpower policy and allocation processes should be designed so as to maintain a high level of human resource utilization and avoid taking actions which undermine the human capital investments already made by individuals and organizations to develop useful skill and knowledge. This seeks to stabilize the availability of job opportunities and development opportunities and avoid waste of human resources.
Stabilization Criteria: The proposed alternative should seek to maintain a high level of human resource utilization and a stable return to the investment in skill and knowledge.

GROWTH - Encouraging the full utilization of its citizens is an important governmental function. Public policy should facilitate the creation of jobs, both public and private, in line with the increase in the labor force. Too fast or too slow job creation may result in unwanted unemployment or inflation. In order to promote use of people's talents, public policy should also seek to provide or to stimulate opportunities to develop knowledge and abilities in directions which are viewed as desirable for the long-term economic and technological growth of the society.
Growth Criteria: The alternative should encourage growth in the number of jobs consistent with the growth in the available labor force and should enhance skill and knowledge in desirable directions.

## WEAPONS AND HUMAN RESOURCES

Moving from the general public policy aims and the general critieria for the evaluation of alternatives in any public organization to those specifically related to the military, we will now illustrate how these public policy and alternative evaluation perspectives on human resources affect the process of weapon program design and deployment. We will examine which MPTS areas are affected in each policy facet and what general guidance might be provided for weapon and forces program designers.

Since the purpose of this paper is to develop a human resource perspective on weapon design and deployment problems, we will assume that alternatives being compared have the same levels of effectiveness. Any possible differential in costs of designing and deploying weapon system alternatives will also be set aside. The following sections illustrate desirable directions strictly from a human resource perspective and do not represent a complete cost-benefit analysis of a given situation. For purposes of exposition, they will address the human resource implications as though they were the only criteria to be used. The very important matter of integrating human resource concerns with cost, benefit and other concerns must be left for future development.

The PRODUCTION facet emphasizes the efficient and humane use of human resources in providing an essential public good or service. The efficiency question is two-fold. First to be considered is, the overall efficiency, regarding whether more people are being used than would be used under some other alternative. A preferred alternative is one which uses fewer human resources to accomplish a necessary function. Therefore, a program or design would be evaluated on the reduction of human resource requirements (staffing levels) over the system proposed to be replaced, the baseline, or some other alternative.

The second part of the efficiency question recognizes that the use of resources in peacetime military service is by its very nature a consumption activity, using resources but producing no goods or services to benefit society directly. There will be some second-order benefits, such as the direct provision of jobs for military and government civilian employees, the indirect provision of jobs in defense contractor companies, and spillover benefits such as technological development and human capital investment. But all of those could be obtained by other means. These other means may provide direct contributions to the nation's output of goods and services for consumption or investment. Since peacetime defense, beyond that needed for deterrence and readiness, is a consumption of resources that provides no direct return to society, the overall number of persons engaged in this activity should be kept to a minimum. This implies that alternatives be evaluated not only on the basis of the number of people to operate and maintain the specific weapon, but also on the impact on the number of people in the military establishment as a whole. Thus, based only on the production criterion, weapons and other programs that reduce the overall size of the armed forces will be preferred.

There is a further implication that deals with the relation between active and reserve military. Since an individual can serve in the reserves while also making a positive contribution to society in some other job, only the minimum number of personnel should be on active duty. This implies that, from a human resource perspective, the nation's overall well-being is enhanced by having a large reserve and a very small active cadre. Equipment then would be preferred that fits the concept of part- time operators and maintainers. Designers should be looking at equipment from the perspective of a reservist whose peacetime military duty involves one weekend a month and two weeks in the summer. A preferred alternative would be one that does not require constant practice in order to maintain the necessary skill levels. Systems are also preferred that correlate military skills with civilian-usable skills.

Observing such guidelines would increase the ability of the services to place more reliance on the reserves, reducing the active forces. This implies that equipment be designed so as to minimize the need for frequent routine maintenance and testing to assure it is in proper working order or the need for regular practice to maintain proficiency. It would be to the nation's advantage to buy equipment that is reserve-capable, in preference to other equipment which cannot be satisfactorily operated or maintained by part-time soldiers or sailors.

The other aspect of the production facet is its impact on people's development opportunities. In terms of the efficient and humane use of people there are several important considerations, the first being whether the design of the alternative takes due account of human factors. That is, the design should avoid unneeded stress on the person, including such human factors as reach, attention span, physical position, and the like. Second, the alternative should be one which minimizes the exposure to safety hazards and any activities, devices or chemicals which might jeopardize health or future employability.

In summary, the production concerns should be those related to human factors, safety, equipment design to reduce strain, minimizing the number of people, and providing a job that can properly be said to require the attributes of people to accomplish.

The DISTRIBUTION facet focuses on the equity with which the job and development opportunities are distributed among the labor force. The labor force here includes only the military, civilian and contractor personnel required to operate, support, train, and maintain the specific weapon upon deployment. Although the legislature or the contracting officer may wish to consider such things as the geographic distribution of jobs by competing manufacturers for the weapon, that is not the focus of the MPTS concern. Rather the focus is on the specific alternative or design. Preferred alternatives will be those that limit the human requirements to those that can reasonably be expected to be available over the next 10-20 years, that use a mix of high and low skilled people, and that minimize the need for unusually high levels of skill or ability, such as eyesight, eye-hand coordination, AFQT score, or college-level reading ability.

Consideration of equity of distribution would favor designs that use low ability persons, such as Category IV avionics maintainers, rather than high ability persons. Preferred alternatives would allow the services to use low talent rather than high talent enlistees, as the latter are more scarce and of more value in the civilian sector. Distribution of opportunities also implies that dispersed training is preferred because it would make training more generally available and not favor those who happen to be stationed near the central training site.

The STABILIZATION facet requires that alternatives be examined in terms of job stability, the level of human resource utilization, and the effects on the usability of existing skill and knowledge. This does not imply a criterion of "no change" from the existing situation but emphasizes continuity in the change process. It would not preclude technological change, for example, but would downgrade any alternative which proposes a change to a different technology without sufficient reason, since such change creates unnecessary turbulence in job and skill requirements and consumes extra resources in adapting to the new system.

In like manner, weapons and programs are preferred that do not create unit turbulence and personnel transfers. This has direct implications for the design of training systems, since dispersed training would be preferred to centralized training. Part-time skill building is preferred to full-time training. Preferred alternatives will be those that build on existing skills, that show design continuity with existing programs and systems, allow the use of previously developed skill and knowledge, provide jobs that minimize surges of effort and staffing levels, and provide a task structure which is fulfilling to the person.

Given the preference for reserves over active duty personnel, the stabilization criteria would favor systems which make it easier for part-timers to achieve and retain appropriate levels of operation and maintenance skills. Continuity of operational layout and maintainer skills become highly valued attributes of the system, as do maintenance aids and training devices which enable a person to get "up to speed" in a minimum amount of time. Similarly, equipment is preferred which conforms to a standard operational layout so that cross-training and upgrading to new equipment are accomplished with minimum time consumption and a concommitant reduction in the deadly risk of error or confusion. Equipment is also preferred that filters and organizes incoming information so as to prevent human information overload.

The GROWTH facet is concerned with the growth in the number of jobs and in development opportunities. Based on the earlier discussion of the desirability of minimum peacetime use of resources in defense, the appropriate evaluation here would be a reduction in the number of persons required to operate, maintain, train and support the program. The development opportunities side, however, is the major focus and it implies the evaluation of programs in terms of the growth in characteristics of the people required. The design of weapon systems, maintenance aids, and training programs, for example, should facilitate continued skill growth of the person, encourage cross-training and use, and relate to other programs so as to develop career ladders and eliminate dead-end jobs and single-use skills. Preferred alternatives would promote skill and knowledge growth by facilitating the use of present job-holders to train new people, since this would increase the job knowledge of both old hands and new. Alternatives that enhance people's motivation, job satisfaction, and independence would also be preferred.

## CONCLUSION

This article has proposed a structure for analysis of the human resource implications of weapon program design and selection decisions. The structure focuses on job opportunities and development opportunities as the areas of principal concern and specifies four important facets of the analysis - Production, Distribution, Stabilization, and Growth. Public policy decision criteria are presented for each facet. Extension of these criteria to the weapon program environment provided initial illustrative decision rules for the acquisition and human resource communities. These illustrative decision rules are really heuristics, or rough rules of thumb, which indicate suggested directions for program design and alternative selection.

Fully meeting the challenge to integrate MPTS along with cost, schedule, and performance into the fabric of weapon system acquisition will require further development of the decision criteria. Criteria development especially needs to address trade-offs and priorities when the rules provide conflicting guidance. For example, dispersed training is preferred to centralized training, but the use of dispersed training might require more trainers, which conflicts with the rule giving preference to designs requiring fewer people. Attention also must be given to the interrelation of MPTS concerns with cost, schedule, and performance specifications. For example, how much additional cost is acceptable to make a piece of equipment fully reserve-capable? Equal cost and effectiveness of alternatives have been assumed throughout this discussion. Since this assumption will seldom hold, program designers and managers must discover how to integrate human resource concerns into cost-effectiveness analyses.

Although the rules will never be perfectly consistent and trade-offs will always be necessary, the use of the proposed framework could aid the development of usable criteria and enable the acquisition community to better respond to the MPTS challenge. The Office of the Secretary of Defense could aid this response by using this structure to develop long-term human resource guidance for service and industry weapon program design and deployment. Such guidance would be responsive to the Secretary of Defense's concern for "...strengthening our ability to assess the total manpower, personnel, training, and safety (MPTS) implications of future weapon systems and equipment ...thereby ensuring that manpower provides maximum combat capability at an acceptable cost."

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# EXPEDITING ACQUISITION MANAGEMENT KNOWLEDGE AND INFORMATION TO CENTERS OF MANAGEMENT EXCELLENCE

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## ABSTRACT

This paper addresses a critical problem in the field of Defense Systems Acquisition Management (DSAM). The 1986 Packard Commission Report says centers of management excellence are required in the large complex enterprise of national defense, but it does not address the crucial DSAM knowledge and information support which the professionals in these centers will require. Support from present DSAM knowledge/information processes and systems is grossly inadequate.

The paper examines the implications of the centers of management excellence concept. Then, it discusses why and how to integrate the normally separate DSAM research and DSAM information assembly and dissemination processes into a more productive closed-loop research and information (R&I) process. This <u>integrated R&I process</u> could expedite timely relevant DSAM knowledge or information when needed by a professional in any center, but only if supported by <u>DSAM knowledge systems</u> with appropriate well-interconnected corporate-memory data banks.

The paper identifies three data bank categories--DSAM Documents, DSAM Expertise, and Ongoing DSAM Research Projects--and describes a Validated DSAM Issues/Problems (VDIP) database. All are essential elements of DSAM knowledge systems that can support an integrated R&I process.

Last, the paper identifies the <u>key</u> element in all effective DSAM knowledge systems--an integrated DSAM Taxonomy-Glossary of core defense acquisition management knowledge and information. Extended, this integrated taxonomy-glossary can provide the common controlled language required to interconnect all DSAM knowledge systems: first, to structure, organize, classify, and index DSAM knowledge and information the same way in <u>all</u> data bases identified above, and then, enable timely retrieval of particular knowledge or information by each professional <u>when</u> each needs it.

DSAM knowledge systems interconnected by a common controlled DSAM language throughout the acquisition community could effectively support the integrated DSAM R&I process. Then, the systems could be used in the process by all DSAM professionals--policy-makers, researchers and doers--to allocate DOD management-research resources more effectively among high-priority DSAM issues, speed creation of new DSAM knowledge, and expedite DSAM knowledge and information to all centers of management excellence.


## INTRODUCTION

The President's Blue Ribbon Commission on Defense Management (Packard Commission) submitted its report, *A Quest for Excellence: Final Report to the President* (1) in June 1986. Throughout my long career in defense systems acquisition, I have never seen a more comprehensive set of recommendations for improving defense acquisition management than the recommendations provided in this report and its appendix. They aim to improve not only the defense systems acquisition management (DSAM) process, but also to promote constructive changes in its overall environment which heretofore has severely limited productivity in management of system acquisitions.

One chapter of the report, "Acquisition Organization and Procedures," recommends extensive changes to improve the acquisition system (a.k.a. process) itself. Equally important, however, the other three chapters--"National Security Planning and Budgeting," "Government-Industry Accountability," and "Military Organization and Command"--recommend major constructive changes in each of these elements of the overall acquisition environment within which DSAM processes operate, and with which they interact in the acquisition of defense systems.

These different environments strongly influence the effectiveness and productivity of the DSAM process used to acquire and modernize defense systems. Their influence is so great that the changes in acquisition organization and procedures recommended by the Commission will effectively improve management of defense acquisitions <u>only if</u>

constructive changes are also made in these three environments. On the other hand, if constructive changes recommended in these environments are coordinated with changes recommended to improve the acquisition process itself, the resultant changes should substantially increase productivity of the whole DSAM process--improve quality, reduce costs, compress schedules, and hasten achievement of intended performance for new or modernized systems.

However, to increase acquisition productivity substantially, several conditions must be met in coordinating changes in both the DSAM process and its environments. First, changes to improve both process and environment must be global, effective throughout the acquisition community--in the administration, the Congress, defense industry, and participating businesses and academia. Second, the changes must be evolutionary since they cannot all be made overnight. Third, the results of evolutionary constructive changes in the acquisition process and its three environments must be continually integrated. Finally, the ability of DSAM professionals (2) must be augmented to use these continually improved and integrated DSAM processes effectively in acquiring and modernizing defense systems.

Two resources are required to realize all of this. First, we need DSAM professionals who are "compound" change-and-operating agents: effective change agents to promote and carry out integrated evolutionary changes in the complex defense acquisition processes and environments; and also effective operating agents, using the evolving processes continuously to acquire, within allocated resources, that which will provide the most adequate defense. Second, but equally important to realizing all of this (and the focus of this paper), relevant knowledge and information must be provided each of these DSAM professionals, as needed to complete each professional's change or operating task at hand.

## MANAGEMENT CONCEPT

The Commission's Chairman, David Packard, wrote in the report's Foreword, "The Commission's recommendations are intended to help establish strong centralized policies that are both sound in themselves and rigidly adhered to throughout the Department of Defense (DoD). In any large organization, policies must be executed through discrete structures. In the large, complex enterprise of national defense, this requires that we cultivate *centers of management excellence* dedicated to advancing DoD's overall goals and objectives." Note that cultivate is the operative action.

### Centers of Management Excellence

He continued, "The Commission's recommendations, if fully implemented will help create an environment in which each DoD component can achieve ever higher standards of performance by summoning forth enthusiasm and dedication of every man and woman involved in accomplishing its mission. Excellence in defense management will not and cannot emerge by legislation or directive. Excellence can flourish ... only where individuals identify with a team, take personal pride in their work, concentrate their unique efforts, develop specialized know-how, and above all constantly explore new and better ways to get their job done."

These attributes of management excellence will only flourish through cultivation in a supportive environment. Achieving and maintaining this environment is a joint responsibility of the Executive Branch and the Congress.

After citing an example of the Commission's intended technique--establishment of strong centralized policies implemented through highly decentralized management structures--Chairman Packard continued, "Despite formidable bureaucratic obstacles, I believe that a centers-of-management-excellence approach can tangibly improve productivity and quality. If widely adopted and steadfastly supported, it could achieve revolutionary progress throughout defense management."

He cited a 1984 example where "DoD began applying this concept to managing its installations as potential centers of excellence, by according installation commanders much greater latitude to run things their own way, cut through red tape, and experiment with new ways of accomplishing their missions. As a result, commanders and their personnel have found more effective means to do their jobs, identified wasteful regulations, and reduced costs while improving quality. The program has shown the increased defense capability that comes by freeing talented people from over-regulation and unlocking their native creativity and enthusiasm."

President Bush and the Congress both want to continue implementing the Packard Commission's recommendations. To succeed, excellence in defense management is required. This excellence can be achieved only through widespread cultivation of centers of management excellence throughout the acquisition community. Their cultivation, as envisioned by David Packard, is a new concept in defense acquisition organization and process. He identified key attributes. However, to determine how best to cultivate the centers throughout the acquisition community, we must also identify their requirements, and how best to meet them.

### Information-Based Organization

Neither Chairman Packard's foreword, nor the Commission's report addresses how professionals working in each center of management excellence will get timely information concerning DoD goals and objectives, or any other critical acquisition knowledge or information relevant to each center's function. Nor do they indicate how each professional can develop/acquire the required specialized know-how, or where each can learn new and better ways in time to do the job. Yet, to function effectively in advancing DoD's goals and objectives, every center's professionals must have timely access to specialized know-how, to relevant information, and to knowledge of better ways to do their jobs, whenever each needs any of these to complete a task at hand.

Peter Drucker provides important insights concerning the attributes of these professionals and centers, and thus, concerning what will be necessary for cultivating, maintaining, and supporting centers of management excellence. Looking toward the future, Drucker foresees "the typical business will be knowledge-based, an organization composed largely of specialists who direct and discipline their own performance through organized feedback from colleagues, customers, and headquarters."

Note the key attributes of this organization--professionals directing and disciplining their own performance through organized feedback, i.e., through timely relevant knowledge and information from appropriate sources. This sounds a lot like Packard's "centers of management excellence."

Calling this an information-based organization, Drucker continues, "Businesses, especially large ones, have little choice but to become information-based....The center of gravity in employment is moving fast from manual and clerical workers to knowledge workers....Economics also dictates change, especially the need for large businesses to innovate....But above all, information technology demands the shift." (3)

We are already seeing a progressive shift toward information-based organization and knowledge workers in large private businesses. But, what about defense acquisition? DOD procurement is the largest business in the world. Defense systems acquisition involves many organizations--large prime contractors, subcontractors, vendors, suppliers, and other businesses, which operate largely under programs managed by military-service program management offices (PMOs) under DOD policy oversight, which in turn, is strongly influenced by both Executive and Congressional oversight. Defense systems acquisition in this complex dynamic environment is becoming increasingly unmanageable under traditional hierarchical organization and management.

As traditional organization and operations become decreasingly effective, there is a critical need to expedite the progressive shift toward information-based organization throughout the defense acquisition community--in businesses, in PMOs, and in defense acquisition policy, oversight and support organizations that are complexly interconnected by contracts for acquiring defense systems. Mr. Packard has pointed the way--cultivate centers of management excellence in all organizations involved in defense acquisition. We must staff each center with professionals who are "compound" change-and-operating agents. But to be effective and increasingly productive, each professional in every center requires both relevant knowledge to function effectively and current information to operate most productively.

## CRUCIAL QUESTION

These conditions and requirements raise a crucial question: How to expedite relevant DSAM knowledge or information:

-- to each knowledge worker, more specifically, each DSAM Professional

-- in any information-based center of acquisition management excellence

-- in any organization throughout the defense acquisition community

-- whenever the professional needs particular knowledge or current information, or both, to accomplish an acquisition task at hand?

I have itemized these requirements to emphasize the full scope of this question. Meeting all of these requirements is crucial to both the cultivation and effective operation of centers of acquisition management excellence throughout the acquisition community. Based on my research, I believe the itemizations are all valid requirements: needed to fully implement the Packard Commission recommendations and to continue constructive change in management of defense acquisition. Doing this should increase acquisition productivity substantially, and better assure our adequate defense in present and foreseeable economic and political environments.

In my research, I examined two serious inherent consequences of the large scope, great complexity and "interactiveness" of the defense acquisition process, which combine to limit productivity in systems acquisition. I found a need for different mind-sets, and for new analytical frameworks and concepts to enable more effective use of DSAM knowledge and information resources in coping with the consequences. (4) I studied past improvements in acquisition management to learn why they did not cope better with the serious consequences, why they were not sufficient to increase productivity in defense systems acquisition substantially. (5) Considering these results, I assembled new concepts which I believe will help cope better with the serious consequences. I proposed three general DOD initiatives for guiding specific research and actions in three interdependent DSAM areas to assure continued substantial increases in defense acquisition productivity. (6) Within these general initiatives, I proposed several urgent first actions to begin broad evolutionary development of DSAM processes and supporting knowledge systems that can increase defense acquisition productivity substantially. (7) This paper discusses how some of the proposed first actions can help answer the crucial question.

Let's consider an integrated process and affiliated supporting systems which can expedite critical DSAM knowledge and information to any DSAM professional, and thus, aid cultivation and effective operations of centers of acquisition management excellence throughout the acquisition community. First, a look at how present DSAM research processes and DSAM information processes can be integrated, then at the supporting systems.

## INTEGRATED RESEARCH AND INFORMATION (R&I) PROCESS

Traditionally, processes concerned with DSAM knowledge and information, although highly interdependent, have been separate processes. For example, separate processes are normally used to pursue the following interdependent knowledge/information goals: to educate; to identify critical issues/problems that need research; to conduct research to generate and report "new" knowledge and information; to assemble, organize and store together in data banks, both the still-useful "old" and "new" knowledge/information; to disseminate knowledge/information by broadcasting selected items through publication; or to disseminate from data banks by selective retrieval to meet a user's specific need.

These processes are traditionally separated by function (e.g., educate, find, generate and report, assemble, and in continuing education--publish "broadcast" selected items, or retrieve to meet specific user needs). The processes are often segregated by mission. For example, the defense acquisition missions of the Defense Systems Management College (DSMC) are: conduct advanced courses, conduct research, assemble and disseminate information, and as the DOD executive agent, provide oversight for the DOD education and training program for the acquisition workforce).(8)

I believe the productivity of every DSAM professional, regardless of DSAM function each performs or mission each supports, can be increased greatly by integrating traditionally separate DSAM knowledge and information processes into a closed-loop Research and Information (R&I) process. This idea is not new. In 1985 I identified the need for an integrated closed-loop DSAM R&I process, and suggested how DSAM professionals could use DSAM knowledge systems in an integrated R&I process to operate more productively.(9)

Now, two new factors increase the importance of this idea and urgency of our national need for a closed-loop DSAM R&I process. First is the increasing realization that the defense budget reductions since 1985 will continue in the foreseeable future. These defense budget reductions will endanger maintaining adequate national defense unless countered by substantial increases in defense acquisition productivity.

The second is recognition of the continuing roles that DSAM professionals must play in centers of acquisition management excellence: as change agents, in implementing recommendations for substantially increasing effectiveness and productivity of acquisition processes in more constructive environments; and as operating agents, in using the improved processes to develop and execute policies effectively in more productive management of defense acquisitions. Chairman Packard started this recognition in the Foreword of the Commission's Final Report, where he states "In the large, complex enterprise of national defense, this (effective execution of acquisition policies) requires that we cultivate *centers of management excellence*..." Reason also indicates that in defense acquisition, centers of management excellence are required in development of acquisition policy, as well as in execution.

Chairman Packard's discussion and example of the centers-of-management-excellence approach triggers further realization: successful cultivation of these centers throughout the defense acquisition community--in DOD, other government departments and agencies, congressional staffs, industry, business and academia--requires that each professional member of every center of acquisition management excellence must have relevant DSAM knowledge to function effectively, and current DSAM information to operate productively in defense acquisition.

Why is this realization important? What are its implications? Meeting this condition for DSAM knowledge and information requires expediting relevant DSAM knowledge or current DSAM information to any center whenever a professional needs either for a task at hand. In turn, this requires correlated development of both an integrated closed-loop R&I process and its vital supporting DSAM knowledge systems which each DSAM professional can query in the R&I process to expedite needed knowledge or information. I will focus first on the integrated process.

## The Closed-loop R&I Process

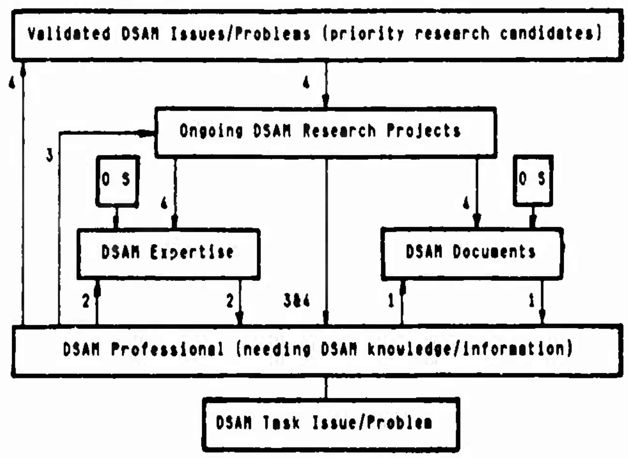


Fig 1. Integrated Research and Information (R&I) Process

Figure 1 is a simplified model of an integrated closed-loop DSAM R&I process. I believe this process is required to support the cultivation and ongoing operations of centers of acquisition management excellence throughout the defense acquisition community. The numbered arrows indicate four processes integrated into the R&I process. The integrated process can be supported by both manual and computerized DSAM knowledge systems. Arrows from the DSAM professional enter four boxes. They represent four categories of DSAM corporate-memory data banks, components of databases of organizations in the acquisition community. These data banks/bases are important elements of the supporting DSAM knowledge systems, which I will discuss after outlining the process.

Any professional could use the integrated process to get particular DSAM knowledge/information for a task at hand. First, the professional would use DSAM knowledge systems to query DSAM Documents data banks for documented knowledge or information, and also DSAM Expertise data banks to locate experts--individuals or organizations--available for consultation. If both queries yield nothing useful, the professional would check Ongoing DSAM Research Projects data banks of DSAM research organizations to identify a principal investigator who has the required, but as yet unpublished, knowledge/information. Success in any of these queries would close the loop by expediting the sought knowledge/information to the professional, enabling him or her to complete the task.

If no query of these data banks produces the required knowledge/information, the professional would register the sought item as a research requirement in the Validated DSAM Issues/Problems (VDIP) database. It would be entered in the Projects Being Evaluated (PBE) data bank of the database, for evaluation by competent authorities. If they validate it as a sound requirement for new DSAM knowledge/information and give it a research priority, the requirement would be transferred to the Validated Candidate Projects (VCP) data bank as a validated project for DSAM research with an assigned research priority. One centralized DOD VDIP database would serve all DSAM research organizations in DOD, and also others in the acquisition community, as the source of validated, high priority, candidate DSAM research projects.

If the professional's requirement receives a high priority, a DSAM research organization which has an interest in the validated candidate, expertise in its DSAM area and the necessary resources, would select and transfer the candidate project to its own Ongoing DSAM Research Projects data bank, and begin research. After completing the project, the principal investigator would first close the loop by expediting the new knowledge/information directly to the initiator professional who needs it to complete a task. Then, the investigator would publish the research results to increase the body of DSAM knowledge; and finally, would add the published report to a DSAM Documents data bank for prompt future retrieval when needed again.

This integrated closed-loop R&I process will save time in solving problem tasks by expediting development of essential new DSAM knowledge, and by communicating both the new and the still useful "old" DSAM knowledge or information, to each professional who needs it. This more efficient process will also free scarce DOD resources for additional high priority DSAM research, saving dollars and increasing DOD research productivity.

## DSAM KNOWLEDGE SYSTEMS

In addition to outlining the process, the numbered arrows on Figure 1 also identify four categories of corporate-memory data banks. All are necessary to serve as principal sources of DSAM knowledge and information in DSAM knowledge systems required to support the integrated R&I process.

The first three boxes--DSAM Documents, DSAM Expertise, Ongoing DSAM Research Projects--represent data banks in distributed databases of organizations involved in defense systems acquisition. Some already exist, serving their respective organizations as in-house acquisition management corporate-memory of useful documents, particular expertise or ongoing research, but these data banks are not properly interconnected to support the integrated DOD R&I process.

The fourth box represents a category that does not yet exist, a database of DSAM issues and problems needing research. The DOD should establish a central Validated DSAM Issues/Problems (VDIP) database. It should include two data banks:

-- Projects Being Evaluated (PBE), for registration of needed research--DSAM problems, issues, even critical voids in DSAM knowledge that need research (identified when requests for specific knowledge/information cannot be satisfied through queries of distributed DSAM data banks).

-- Validated Candidate Projects (VCP), for candidate DSAM research projects--transferred from the PBE data bank, after being validated as requiring research and given a research priority by competent authorities during periodic reviews of research requirements listed in the PBE.

This central Validated DSAM Issues/Problems database could provide high-priority validated research topics to all DSAM research organizations and could serve all DSAM knowledge systems.

Additionally, the VDIP database would give professionals in centers of management excellence, strong support for constructive changes in the environment of defense acquisition--changes which would solve perennial acquisition problems stemming from the environment (e.g., problems that have continually reduced productivity in defense system acquisitions, such as annual congressional funding of multi-year system acquisition programs). Recurring registrations of the same item--environment-based problem, DSAM-process issue, information void--in both the PBE and VCP data banks will accumulate statistical evidence of needs for change. This will focus attention on specific environment-based problems which many organizations have encountered, as well as on widespread DSAM process problems and issues.

Since most of the Packard Commission Report concerned problems stemming from environments of defense acquisition, I would anticipate numerous registrations for some constructive changes in the national security planning and budgeting environment, in laws regulating the government-industry accountability environment, and in the government personnel management and training environment. This would build strong evidence and pressure for the Congress and the Executive Branch to make constructive changes that would result in widespread improvements in the acquisition process, including increased stability of funding for programs that are proceeding according to plan.

Not identified on Figure 1, but the <u>key</u> element of every DSAM knowledge system, is the integrated DSAM Taxonomy-Glossary of core defense acquisition management knowledge and information. (10) An extended DSAM Taxonomy-Glossary is needed by every DSAM knowledge system as the common controlled-language for classifying, organizing, indexing, storing and retrieving knowledge and information from corporate-memory data banks. When <u>all</u> DSAM knowledge systems in the acquisition community are interconnected by a common DSAM language, they will provide essential integrated systems support for the integrated DSAM R&I process.

The question where to start developing the vital DSAM knowledge systems required in the integrated

R&I process must be answered by the professionals. Those interested in gaining the benefits of the integrated R&I process in their areas of defense acquisition must support development of initial groups of operational data banks in these DSAM areas. Their experience will demonstrate how DSAM knowledge systems can support the integrated R&I process and encourage continued evolutionary development of data banks in other DSAM areas.

When these DSAM data banks become widespread, any professional in a center acquisition management excellence can use the DSAM knowledge systems to expedite needed job-knowledge or task-information whenever the professional seeks either, or both, for a task at hand. As more organizations develop appropriate DSAM corporate-memory data banks to increase their own productivity, effective support of the integrated R&I process throughout the acquisition community will increase.

## CONCLUSIONS/SUMMARY

This simplified explanation of how an integrated DSAM research-and-information process can expedite DSAM knowledge and information to professionals in centers of acquisition management excellence, indicates the need to begin now preparing to integrate the separate DSAM research and DSAM information-assembly-and-dissemination processes into a much more efficient and effective closed-loop R&I process. The new integrated process will reduce waste of scarce DOD research resources by reducing unwarranted duplication of research, speed development of vital new DSAM knowledge, and expedite DSAM knowledge and information to professionals in centers of management excellence throughout the acquisition community.

In addition, the explanation illustrates how evolutionary development of DSAM knowledge systems (which are required to support the integrated R&I process) can increase flow of widely useful information throughout the acquisition community. It accentuates the urgency to begin development of the DSAM Taxonomy-Glossary (a prerequisite to developing and connecting DSAM data banks throughout the defense acquisition community), thus making integrated DSAM knowledge systems possible.

To start both the evolution of integrated DSAM knowledge systems throughout the defense acquisition community and the development of an integrated R&I process, the DOD should begin the following actions:

-- Cultivate centers of acquisition management excellence throughout the acquisition community

-- Support research to develop the integrated DSAM Taxonomy-Glossary

-- Encourage development of distributed DSAM Knowledge System data banks interconnected by the common controlled language of an extended DSAM Taxonomy-Glossary, including data banks for DSAM documents and expertise and for information about ongoing DSAM research.

-- Establish a central DOD database, Validated DSAM Research Issues/Problems, to support all DSAM knowledge systems.

Successful initiation of these actions:

-- Will begin evolutionary development of increasingly effective integrated DSAM knowledge systems

-- That can support an integrated DSAM Research & Information process

-- That can expedite critical systems acquisition management knowledge and information to DSAM professionals in centers of defense acquisition management excellence

-- Which will substantially increase productivity in defense systems acquisition to better assure our adequate national defense in the foreseeable economic, political and world environments.

## ENDNOTES

1. President's Blue Ribbon Commission on Defense Management. 1986. *A Quest for Excellence: Final Report to the President*. Washington, D.C.: U.S. Government Printing Office, June, 115 pages.

2. The term DSAM professional, as used in this paper, includes any government, contractor, academic or other knowledge worker who uses DSAM knowledge and information professionally in his or her job in support of the defense systems acquisition process--for example, DSAM policy-makers, program/project managers/directors and their staffs, support managers, congressional staffs and members of the Congress, educators, researchers, and DSAM information managers, including librarians who maintain documented DSAM knowledge and know other accessible sources of DSAM knowledge and information for ready access when needed by a professional.

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# "THE RIGHT STUFF"
# RESULTS OF DSMC'S PROGRAM MANAGER COMPETENCY STUDY

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## ABSTRACT

This paper highlights the results of a major study conducted over the past year by the Defense Systems Management College to identify the competencies of successful program managers in the weapon systems acquisition process. In-depth interviews were conducted with 56 program managers and an additional 353 acquisition professionals were surveyed to determine the most critical competencies (technical expertise, leadership and management skills) associated with successful program managers. The competency model developed from this study can be used to prepare or modify training programs, as a guide for selection or career development, and as a means for acquisition organizations to explain their goals for effective performance.

## INTRODUCTION

What characteristics distinguish DoD's best acquisition program managers? The Defense Systems Management College (DSMC) sought the answer to this question in a recently completed study which identified the competencies (technical expertise, management and leadership skills) possessed by a select group of program managers from the service acquisition commands. The study was based on the premise that the best way to find out what it takes to be a good program manager is to analyze the job's outstanding performers and identify what they do that makes them so effective. The study included in-depth interviews with program managers and a follow-on survey of acquisition professionals. An article in the January-February 1989 Program Manager (1:42-44) outlines the job competency assessment process used in the study and its theoretical base. This paper presents the study findings and recommendations.

## STUDY METHODOLOGY

The interview sample consisted of 56 program managers and deputy program managers drawn from the Army, Navy and Air Force acquisition commands. This sample included both major and non-major programs as well as programs in each phase of the acquisition life cycle. Two groups of program managers were selected for interviews: a group designated as outstanding performers and a contrasting group of effective (or more typical) performers. Nominations were received from the program executive officer (PEO) level in each service. In addition, a competency assessment survey, completed on each nominee by several peers and subordinates, was used to clarify the final nomination categories. The two groups were used to identify competency requirements of program managers (those shared by both groups) as well as those competencies that distinguish the outstanding performers from their contemporaries. The identity of the groups was kept confidential: neither the interviewers or interviewees were given this information.

The interviews generated 217 critical situations involving the program managers. Situations described most frequently were contracting (47), personnel management (31), test and evaluation (26), and budgeting and funds management (19). The interview transcripts were analyzed and then systematically coded to identify distinguishing behaviors exhibited by the program managers. These behaviors then were grouped into related categories and given descriptive names by the research group. This constituted the preliminary competency model.

Since the interview sample was relatively small, a follow-on survey was conducted to validate the competency model and test its relevance to a broader group of acquisition professionals. The written survey required participants to prioritize separate lists of competencies and acquisition knowledge areas and also indicate in which areas they most needed training.

## PROGRAM MANAGER COMPETENCY MODEL

The final program manager competency model is displayed in Figure 1. Competencies were grouped by factor analysis, i.e., those which tended to occur together in the interview data. Competency names and descriptions are listed below:

1. Sense of Ownership/Mission. Sees self as responsible for the program; articulates problems or issues from broader organizational or mission perspective.

2. Political Awareness. Knows who the influential players are, what they want and how best to work with them.

3. Relationship Development. Spends time and energy getting to know program sponsors, users and contractors.

4. Strategic Influence. Builds coalitions and orchestrates situations to overcome obstacles and obtain support.

5. Interpersonal Assessment. Identifies the specific interests, motivations, strengths and weaknesses of others.

6. Assertiveness. Takes or maintains positions despite anticipated resistance or opposition from influential others.

7. Managerial Orientation. Gets work done through the efforts of others.

8. Results Orientation. Evaluates performance in terms of accomplishing specific goals or meeting specific standards.

9. Critical Inquiry. Explores critical issues that are not being explicitly addressed by others.

10. Long-Term Perspective. Anticipates and plans for future issues and problems.

11. Focus on Excellence. Strives for the highest standards regardless of circumstances.

12. Inovativeness/Initiative. Champions and pushes new ways of meeting program requirements.

13. Optimizing. Makes decisions after carefully evaluating advantages and disadvantages.

14. Systematic Thinking. Organizes and analyzes problems methodically.

15. Action Orientation. Reacts to problems energetically and with a sense of urgency.

16. Proactive Information Gathering. Systematically collects and reviews information.

Further analysis of the interview data revealed that the subgroup of outstanding program managers scored significantly higher in six of the competencies. These are coded (*) in Figure 1. All but one of these competencies relate to managing the external environment.

As an example of Sense of Ownership/Mission, a program manager described his frustration at being potentially frozen out of a key meeting:

> Why did I want to get involved in the treaty? The reason is that it affected my system. I am in charge of the full systems management. That is my system. You better talk to me. If you won't talk to me, I will kick down your door. If you throw me out, I will go find somebody else or I will come in your back door. I am responsible for this system.

Another program manager used Strategic Influence to gain support for his acquisition strategy:

> I finally recognized that I needed heavy hitters with more influence and authority than I had, so I got a meeting with the program executive office, the head of procurement, my staff, an attorney advisor, the Army's contract policy expert. In other words, I had to go in there and literally stack the deck in terms of influence and independent representatives who would vouch for what I had said.

Several subcategories of interview participants were also compared. However, minimal differences were found in the competencies across the services, program phase or program size.

Competency rankings from the follow-up survey (as illustrated in Figure 2) correlated very well with the competency model. Only 1 of the 16 competencies in the model (assertiveness which is not socially desirable) was ranked by program managers lower than 18 in a pool of 27 competencies (additional socially desirable characteristics were added to make the ranking more rigorous). In contrast, the acquisition professionals' rankings for their jobs reflected a very different set of competencies. For example, professionalism (defined as technical expertise) was ranked 1st by acquisition professionals and 23rd by program managers (see Figure 2).

## ACQUISITION KNOWLEDGE AREAS

As part of the survey, respondents were asked to rank the importance of acquisition knowledge areas for their jobs. Program managers and acquisition professionals both emphasized the policy and management knowledge areas as shown in the first column of Figure 3.

## TRAINING NEEDS

Survey respondents were also asked to identify those acquisition knowledge areas and competencies where they could most benefit from additional training. When compared to the survey importance rankings, fewer respondents identified training needs in either category. As shown in the second column of Figure 3, program managers and acquisition professionals emphasized software and several business management functions for additional training. These training needs differ considerably from the importance categories in the first column. One possible explanation is that respondents felt more satisfied with their level of acquisition policy and management knowledge than with other supporting functional disciplines, especially those in the business area.

None of the competencies were emphasized for additional training (based on the 33% threshold used in Figure 3). The most requested was interpersonal assessment at 22%. Several factors may have contributed to this result. The program managers and acquisition professionals were not aware of this study which identified the competencies as being critical to effective performance. They also may lack objective evaluation of their competencies or assume they possess them by virtue of their managerial experience or professional education. Finally, they may perceive such competencies as natural talents and therefore not trainable. Further analysis is needed to clarify this result.

### Summary of Findings

I. Sixteen competencies were identified from program manager interviews and confirmed by a follow-on survey.

II. Six of these competencies, based on frequency, most differentiated outstanding from effective program managers.

III. Acquisition professionals identified and prioritized a different set of competencies than program managers.

IV. Minimal difference exists in the sixteen competencies across the services, program phase or program size.

V. Program managers and acquisition professionals emphasized the importance of acquisition policy and management knowledge areas.

VI. Program managers and acquisition professionals reported a need for training in software and several business functions.

### Recommendations

This study was done to provide data to improve program management performance by identifying the competencies required of effective program managers. The first recommendation is to make the acquisition community aware of the competencies found in this study. This article, the upcoming final study report, or a briefing by the research team could serve this purpose.

The second recommendation is to use the study results to assess the compatibility of current acquisition training content and methodologies with the program manager competencies. "Too often training programs attempt to 'teach the fundamentals' using lectures, readings, case discussions, films, and dynamic speakers to transmit knowledge to course participants. Unfortunately, it is usually not the lack of knowledge, but the inability to <u>use</u> knowledge that limits effective managerial behavior." (2:4) The nature of the competencies (management and leadership skills) suggests that acquisition training programs need to move beyond structured presentation of acquisition knowledge to integration of these knowledge areas with the higher order skills (competencies) necessary to be effective in the real world situations faced by the program managers in our study. Experience with the Looking Glass management simulation at DSMC (3:29-39) suggests that senior military and civilian acquisition managers may still need considerable improvement in many of the identified competencies, even though they have extensive prior management experience and professional education.

Practical exercises stressing program management problem solving and decision making in real acquisition situations would be most likely to succeed with such students. These exercises must be followed with evaluation and feedback to students on how their individual competencies contributed to or detracted from effective performance on the exercises. Students' need for training will also vary widely. This suggests course electives which group students with similar development needs as well as personal development plans and continuing education opportunities after students return to their jobs.

The third recommendation is to use the study findings to help structure service acquisition career paths. Entrance into acquisition career fields and selection for training and development assignments should be based as much on competencies (especially for key assignments) as on knowledge and experience.

Finally, to aid in implementing the above recommendations, further research is needed to identify the extent to which the program manager competencies are important to other key acquisition positions (such as chief engineer, business/financial manager, logistics manager, and contracting officer). Considering the program office as a team, it would be very useful to identify those competencies required by all key acquisition professionals and those which may be compensated for if possessed by other members of the group. Also of interest is the identification and comparison of industry program management competencies with those of their DoD counterparts.


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Figure 1.

## PROGRAM MANAGER COMPETENCY MODEL

**Managing the External Environment**

- • 1. Sense of Ownership/Mission
- • 2. Political Awareness
- • 3. Relationship Development
- • 4. Strategic Influence
- • 5. Interpersonal Assessment
- 6. Assertiveness

**Managing the Internal Environment**

- 7. Managerial Orientation
- 8. Results Orientation
- 9. Critical Inquiry

**Managing for Enhanced Performance**

- 10. Long-term Perspective
- 11. Focus on Excellence
- 12. Innovativeness/Initiative
- 13. Optimizing
- 14. Systematic Thinking

**Proactivity**

- •15. Action Orientation
- 16. Proactive Information Gathering

• Competencies which distinguish outstanding from effective program managers (at p < .03) based on frequency of demonstration

Figure 2.

## SURVEY VALIDATION OF PM COMPETENCIES

| Competencies | Rank Order of Importance: Program Managers (N=128) | Other Acq. Professionals (N=225) |
| --- | --- | --- |
| Sense of Ownership/ Mission | 1 | 17 |
| Long-Term Perspective | 2 | 22 |
| Managerial Orientation | 3 | 21 |
| Political Awareness | 4 | 18 |
| Optimizing | 5 | 2 |
| Professionalism (Technical Expertise) | 23 | 1 |

Figure 3.

### ACQUISITION KNOWLEDGE AREAS AND TRAINING NEEDS

| | Important for Job [1] | Training Needed [2] |
| --- | --- | --- |
| **TECHNICAL KNOWLEDGE** | | |
| Systems Engineering | X X | |
| Logistics | | |
| Manufacturing/Production | | |
| Fielding | | |
| Software | | X X |
| Test and Evaluation | | |
| **BUSINESS KNOWLEDGE** | | |
| Cost Estimating | | X X |
| Budgeting and Funding Management | X X | X X |
| Contracting | | X X |
| Contract Finance | | X |
| Cost/Schedule Control Systems | | |
| **POLICY KNOWLEDGE** | | |
| Acquisition Policy | X X | |
| Acquisition Strategy | X X | |
| Acquisition Organizations | X X | |
| **MANAGEMENT KNOWLEDGE** | | |
| Systems Management | X | |
| Management Practices | X X | |
| Personnel Management | X X | |
| Joint Service/Multi-national Program Management | | |

X = Indicated by (128) Program Managers
X X = Indicated by (128) Program Managers and (225) Acquisition Professionals
[1] At least half the respondents indicated high level of expertise was needed for their job.
[2] Identified by at least a third of the respondents

# WARRANTIES

# ACQUISITION PLANNING CONSIDERATIONS FOR THE WEAPON SYSTEM WARRANTY ACT

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## ABSTRACT

This paper discusses acquisition planning considerations involved with implementing the Weapon System Warranty Act (WSWA) in procurement of major Department of Defense (DOD) weapon systems. The WSWA requirements can have a significant effect on the DOD and companies supplying its major weapon systems. Readers should note a warranty for an entire weapon system is both a complex as well as a relatively new concept. WSWA topics discussed are: history, applicability, concerns, and acquisition planning implications. Specific recommendations on how to efficiently and effectively plan to comply with the WSWA are discussed.


## INTRODUCTION

Congress passed the WSWA as a means to improve the quality of major weapon systems purchased by the DOD. The impetus for this action was some well-publicized cases of weapon system failures such as poor accuracy of the Maverick air-to-surface missile. The WSWA was implemented in two stages. The first version (passed in 1984) was Public Law (P.L.) 98-212 which was superseded by P.L. 98-525. Public Law 98-525 addressed many of the shortcomings of the 1984 law.

Prior to the enactment of the WSWA, the predominately used DOD warranties were the Correction of Deficiency (COD) Clause in the Armed Services Procurement Regulation (ASPR) and the Defense Acquisition Regulation (DAR) and the Reliability Improvement Warranty (RIW). The Federal Acquisition Regulation (FAR) replaced the DAR in April 1984 and is currently the governing DOD acquisition directive.

The COD clause was the predominant form of warranty used prior to the WSWA. The clause focused mainly on materials and workmanship. Performance, per se, was not warranted. For example, many U.S. Air Force (USAF) system program offices did not tailor warranties to their specific needs. Instead they simply inserted the standard COD clause from the ASPR or DAR into their respective weapon system contracts. This situation occurred since the guidelines for preparing and administering warranties under the DAR and ASPR were few and far between. Guidance for even component warranties was vague. As a result, there was little emphasis on coordinating warranty management between the buying, contract administration, and using activities. Nor was there any emphasis on performing warranty cost-benefit analyses (CBAs). Overall, there was little real emphasis on the use of warranties and their impact on design and supportability. Rather, USAF (buying) program offices focused their energies on cost, schedule, and technical performance of the weapon system. Logistics issues such as warranties were a secondary concern.

Both the COD and RIW were focused on the weapon system's components. Under ASPR and DAR the Government became a self-insurer of the overall weapon system after final acceptance occurred. This meant the Government assumed the risk of performance for the system. Specific identifiable defects were corrected by the component manufacturer who warranted the defective item. Overall, it was believed the self-insurer approach was more cost-effective than paying a contractor for a warranty or similar form of insurance.

## WSWA REQUIREMENTS

The WSWA, 10 USC Section 2403 (Major weapon system: contractor guarantees), requires system-level warranties for all major Department of Defense weapon systems used directly by the Armed Forces for combat. As implemented in the DOD FAR Supplement (DFARS), the WSWA also requires warranties for major subsystems. Spare, repair, or replenishment parts are not covered by the WSWA requirements. The DFARS Subpart 246.7 provides guidance in this area:

(a) Unless waived under 246.770-9, after 1 January 1985, the Military Departments and Defense Agencies may not enter into a contract for the production of a weapon system with a unit weapon system cost of more than $100,000 or for which the eventual total procurement cost is in excess of $10,000,000, unless:

(1) a prime contractor for the weapon system provides the United States with written warranties that --

(i) the weapon systems provided under the contract conform to the design and manufacturing requirements specifically delineated in the contract (or any modification to that contract),

(ii) the weapon systems provided under the contract are free from all defects in materials and workmanship at the time of acceptance or delivery as specified in the contract; and

(iii) the weapon systems, if manufactured in mature full-scale production, conform to the essential performance requirements (EPRs) as specifically delineated in the contract (or any modification to that contract);

(2) the contract terms provide that, in the event the weapon system fails to meet the terms of the above warranties, the contracting officer may -

(i) require the contractor to promptly take such corrective action as necessary (e.g., repair, replace and/or redesign) at no additional cost to the United States,

(ii) require the contractor to pay costs reasonably incurred by the United States in taking necessary corrective action, or

(iii) equitably reduce the contract price,

(b) Contracting officers may require warranties that provide greater coverage and remedies than specified above, such as including an essential performance requirements warranty in other than a mature full-scale production contract. (1:246.7-4)

The term "mature full-scale production" requires additional explanation. It is defined as production exceeding the lesser of (a) the initial production quantity (the number of units contracted for in the first program year of a full-scale production) or (b) one-tenth of the eventual total production quantity. The term "one-tenth of the eventual total production" is intended to mean one-tenth at the time the first production contract is signed. The intent of this qualification to the WSWA was to allow for a better understanding of the capabilities of a weapon system before requiring a contractor to warrant its performance. (2:4)

Waivers to the above requirements can be obtained depending on the circumstances. DFARS guidance on waivers to the WSWA is described below.

> One or more of the weapon system warranties required by 246.770-2 may be waived if such waiver is in the interest of national defense or if the warranty to be obtained would not be cost-effective. Waivers may be granted by the Secretary of Defense, by the Assistant Secretary of Defense (Acquisition and Logistics) for the Defense agencies without the power to redelegate, or by the Secretaries of the Army, Navy and Air Force with the power to redelegate to no lower than Assistant Secretary of the Military Department. Class waivers may be granted where justified. (1:246.7-6)

It is also important to note: "The WSWA and its implementing directives apply to all production contracts for weapon systems, regardless of whether the contract is fixed-price, incentive, cost-reimbursement, or any other type". (2:2) Exclusions to the WSWA are listed below:

- Misuse or improper operation, repair, or maintenance of the system by the Government;
- Defects or failures arising out of combat damage;
- Normal wear and tear;
- Failure of subsystems, components, or parts - including spare parts - provided by other contractors; (2:4)
- If the warranty is not cost-effective;
- Government furnished equipment (with limited allowances); (3)
- Foreign military sales production contracts (do not require mandatory WSWA coverage); and
- Alternate source contractors (may be exempted by the Agency head from the EPR warranty requirements until that contractor manufactures the first 10% of the eventual total production quantity anticipated to be acquired from that contractor). (1:246.7-5)

Some agencies have expanded on the DFARS guidance. For example, the Air Force issued detailed WSWA instructions to its field activities in Air Force Regulation (AFR) AFR 70-11 in December 1988. AFR 70-11 provides detailed instructions in the following major WSWA management areas: planning, waivers, administration, and cost-benefit analyses. The regulation also establishes a specific list of duties and responsibilities of key WSWA policy and implementation offices such as: the Air Force Secretariat; Air Force Systems Command; Air Force Logistics Command; the Using Command; Air Training Command; Air Force Operational Test and Evaluation Center; and the USAF Product Performance Agreement Center. (4)

It is important to note the DFARS allows the contracting officer (CO) some discretion when it comes to tailoring system-level warranties. DFARS 246.770-3 allows tailoring since "... the objectives and circumstances vary considerably among weapon system acquisition programs, contracting officers shall appropriately tailor the required warranties on a case-by-case basis, including remedies, exclusions, limitations, and duration". (1:246.7-4) A CO may narrow the scope of the warranty as well as limiting the contractor's liability. A key reason for tailoring is to ensure cost-effectiveness. An example of warranty tailoring could occur in the situation referenced by The Government Contractor Briefing Papers which states "It is not clear how the concept of 'mature full-scale production' can be applied to one or a few combat systems, e.g., an aircraft carrier". (2:4)

## WSWA CONCERNS

A major concern cited with life-cycle cost aspects of WSWA implementation is the cost of warranty administration. Other concerns associated with the WSWA are: 1) difficulty with measuring and quantifying all costs associated with the warranty; 2) potential conflicts with the component breakout philosophy since prime contractors may build more components in-house to reduce their risk; 3) problems with invalidating the warranty when warranted and non-warranted parts of the same weapon system are interchanged; and 4) over-reliance on contractor support (for WSWA reasons) for weapon system repair which could reduce war fighting capability. Program Manager offers additional insight into the latter concern:

> Obviously, contractors will not be at every field location of their systems. Systems under warranty will either wait for field service by contractor personnel or will be shipped to contractors' facilities for repair. In either case the net result will be an increased delay in effecting the necessary repair of an inoperable system and, thus, decreased readiness. As more systems are fielded under warranty, the more readiness will be effected. I would not view this as a devastating blow to readiness in that at any one time the majority of fielded systems will not be under warranty, but I would expect to find isolated pockets of poor readiness on selected warranted systems. Thus, our newer and most effective systems will be effected the most as they progress through the warranty period. (5:8)

Another major concern is the difference between warranties on commercial and military items. The Government, unlike commercial customers, controls the design and performance baseline. Military items are used in very demanding operational environments and are subjected to extremes in temperatures, vibration, and acceleration. Military weapon systems usually push state-of-the-art technology, whereas commercial systems usually rely on evolutionary product development. For example the B-2 "Stealth" bomber is a quantum leap in technology from its predecessor the B-1B bomber. Similar type weapon systems could also present the same type of recurring issues.

Design control is a key issue since the DOD frequently exercises its unilateral contractual rights to change the design and performance parameters of its weapon systems. Additionally, DOD frequently overlaps development and production; this practice is known as concurrency. Concurrency, which can involve significant configuration changes, has the effect of increasing warranty-related risks since "production contracts are often negotiated and awarded while the weapon system is still being developed or verified". (2:7-8) These baseline changes can have serious consequences on the applicability of the warranty depending on the extend of the change. For the WSWA contractual requirements to be effective, a stable (and hence warrantable) configuration is best. There is a fundamental issue of fairness in attempting to hold a contractor liable for a warranty under the above conditions. The contractor's warranty risk can be mitigated by development and test programs prior to implementation of contractual WSWA requirements.

Use of too many detailed, overlapping, and potentially conflicting specifications also poses a threat to effective warranty management. This is especially true if the specifications cited are EPRs. The trend of increasing weapon system complexity leads to increased costs and difficulty with administering and enforcing WSWA contractual requirements.

Warranties can also have other adverse effects. For example they could result in increasing the overall cost of weapon system acquisition. Program Manager rotes: "Depending on the maturation of the product, figures ranging as low as 1 percent to as high as 10 percent of the acquisition cost could be devoted to cover the manufacturer's risk against warranty provisions". (5:7) Increased risk could also reduce the qualitative level of superiority U.S. weapon systems enjoy. This concern is summarized below.

> It would appear reasonable that warranties would be a disincentive in advancing the state of the art and that we would see a slower and much more cautious approach in developing new military hardware. Some would argue that this would erode our technical superiority while others would argue that we would have much more reliable equipment in the field. To some extert, both are probably true. (5:9)

## WARRANTY PLANNING ISSUES

Proper planning is essential to integrate the statutory warranty requirements into the particular weapon system's overall design, performance, and supportability baseline. This is necessary to ensure cost-effective acquisition and life cycle administration. A system-level warranty is best if the Government proposes and the contractor agrees to accept it in the earlier stages of program development, e.g., full scale development or earlier. Contractor acceptance of the warranty should occur as part of an up-front formal source selection process. WSWA elements should be formal elements of a source selection criteria. The competitive environment helps ensure the Government obtains a meaningful and cost-effective warranty. A good example of this was the extended warranty coverage received by the Air Force during its competition of the Alternate Fighter Engine Program between General Electric and Pratt & Whitney; Congress estimated an approximate $2 billion life-cycle cost savings due to warranty competition on key engine parts.

Effective selection of essential performance requirements is a must. Kennedy and Freeman make the following comments about the need for effective selection of EPRs given a weapon system specification may contain thousands of such parameters:

> Since a valid warranty must be verifiable and enforceable, each EPR candidate must be screened for these two traits. A contractor can only be held responsible for an item for which he has been granted design authority. That authority must be explicitly stated in the contract. The system specifications are normally the legally binding transmission of requirements from the Government to the contractor. Each essential performance candidate must be included in the specification to be viable. If it is not in the specification, it must be eliminated. However, before eliminating the candidate, the warranty manager should discuss the candidate with design engineers and program management. It may be that the candidate was inadvertently omitted. An EPR candidate which is not in the specification but which is a true requirement should be added to the specification. (6:34-35)

Warranty planning should also consider the trade-offs between component breakout policy (to promote competition) and the difficulty with managing and enforcing the various vendor warranties. Contract Management offers additional insight into this situation.

> ... procurement policies are directed toward early breakout of replenishment buys in order to achieve the benefits of competition. Consequently, it is easy to foresee a series of item-oriented warranties that also differ from contract to contract or vendor to vendor. This affects not only the enforcement of the weapon system's warranty provisions, but also requires a management information system capable of tracking the items by contract and serial number. The net result places an additional burden on the lower levels of maintenance and supply - the very level where the DOD is attempting to reduce workload. This also introduces the possibility that the cost of warranty administration may exceed the benefits. (7:17)

PRACTICAL IMPLICATIONS OF THE WSWA

The WSWA is significantly different from prior DOD warranty provisions. The major change is the specific requirement to warranty performance for weapon systems. The emphasis is also changed from component-level to system-level warranties. The WSWA imposes statutory, as opposed to regulatory requirements, on the prime contractor to provide three types of warranties for a weapon system, i.e., 1) freedom from defects in materials and workmanship; 2) conformance to essential performance requirements; and 3) conformance to design and manufacturing requirements. As a result, the Government now minimizes its role as a self-insurer of their weapon systems. Consequently, the responsibility for remedying defects has shifted from the Government to the prime contractor. The WSWA means: 1) the DOD will not depend on implied versus explicit warranties and 2) specified EPRs must be used.

Implications for prime defense contractors are summarized below based on an excerpt from The Government Contractor Briefing Papers.

- Contractors should realize their bargaining strength has a direct affect on their ability to obtain a more favorable warranty position such as price, terms, or waivers. Bargaining strength is influenced by such factors as market structure, e.g., sole source, dual source, or multiple sources.

- When appropriate, contractors should try to have performance requirements expressed as an objective, target, goal or range. This approach can be enhanced with use of price incentives.

- A contractor should not agree to warrant performance requirements that have not been adequately verified.

- Contractors should try to obtain exclusions from the warranties for the many types of defects over which they have no control.

- Contractors should try to negotiate a limitation of their liability for defects.

- The warranty should state a precise duration.

- The contractor should consider establishing their own warranty management staff to deal with WSWA related contractual issues.

- Prime contractors should negotiate warranties with their subcontractors which will guarantee the prime can fulfill his/her warranty obligation to the Government.

- Contractors should consider doing their own CBA. This could assist them with obtaining a total or partial waiver to the three required WSWA warranties. The contractor developed CBA could also assist them with arguing certain EPRs should be excluded from the warranty since they are not cost-effective. (2:9-10)

## SPECIFIC WARRANTY PLANNING ELEMENTS

Warranty use must be balanced between protecting public interest, cost-effectiveness, and military utility. Warranty planning is most beneficial during the conceptual phase since many critical life-cycle cost decisions concerning such items as cost and supportability have not yet been made. AFR 70-11 notes "contractors must be alerted early in the acquisition cycle, ideally no later than the demonstration/validation phase, that the Government intends to require a performance warranty under the production contract." (4:4) Warranty planning affects critical logistics areas such as system design, reliability, spares level, maintainability, and support manning. Warranty planning also affects such decisions as required maintenance levels and overall acquisition strategy. Hence the need for an integrated approach. Specific areas requiring attention are discussed below.

- The cost-benefit analysis is used to determine if the weapon system warranty is cost-effective. As a result, warranty cost-benefit analysis models must be valid and realistic. Government contracting personnel should not overrely on the contractor to price the warranty. Government personnel need to perform their own independent CBA; part of this analysis should be to ensure there is sufficient data to validate the CBA model. According to an ARINC Research Corporation report, the following general categories of costs can be used in determining warranty cost-effectiveness: reliability, maintainability, readiness, logistic flow, initial acquisition cost, support costs, contract price adjustment, and transition costs. (8) Warranty pricing (for negotiation purposes) is a difficult but not impossible undertaking. To complicate the situation, warranty costs incurred during design and production are very difficult to segregate from normal costs. The problems of estimating cost and benefit are further compounded by the lack of historical data on which to base a warranty price. Use of warranty testing may help with warranty pricing since it builds a knowledge base and reduces risk.

- Warranty administration is a significant cost to be considered in development of an overall WSWA implementation strategy. Administration costs should be considered over the entire weapon system's life-cycle. Administration costs should be integral to any CBA.

- A formal feedback mechanism for user and/or contract administration offices to provide warranty performance data back to buying offices is required. The purpose of providing this data is to: 1) ensure future buys of the same weapon system realize a better price for the warranty and/or 2) improve or tighten the performance requirements. Depending on the situation, warranty costs may need to be tracked individually. The DFARS notes "The acquisition cost of a warranty may be included as part of an item's price or may be set forth as a separate contract line item". (1:246.7-1) Care must be taken to ensure a separate warranty contract line item does not co-mingle its cost with other system elements.

- It is essential to establish management and technical interfaces with the appropriate contract administration, logistics support, and using activities to implement key warranty administration activities such as obtaining performance data and setting up warranty repair procedures and assuring WSWA provisions will be enforceable using existing systems or procedures as required in DFARS 246.7. Of special importance is the need to involve the logisticians early on. Logisticians can help the contract administration office with contract enforcement by developing procedures to ensure warranted items are not inadvertently repaired by Government and determining which items are cost-effective to warrant. The logistician can also assist with establishing provisions for Government maintenance.

- Transportation costs for repair of warranted items need to be considered. The contract should state whether the Government or manufacturer pays for transportation to the repair facility.

- WSWA use requires a proper contract type and structure. Effective warranty clauses must be used in the contract. Critical issues are determination of EPRs, length of coverage, and liability flow down from prime to subcontractors for defects. The latter is especially important given the increased use of contractor teaming arrangements for major weapon systems. Successful implementation of these items requires effective training of acquisition personnel.

- Warranted items should be properly marked to ensure effective and efficient administration. This also helps ensure the Government does not invalidate the warranty by inadvertently opening a sealed (warranted) part.

- A separate warranty administration plan should be developed. The plan should discuss in detail procedures for warranty processing at field activities. Warranty administration planning should consider the weapon system's entire life-cycle.

- The Government should consider a wide variety of contractual remedies in case of contractor nonperformance. The usual method of recompensation is a price adjustment. However other forms of compensation should also be considered. For example the Air Force C-17 program office used "cash reductions on the price of spares, or the arranging for no-cost repairs or replacements". (9:16)

- Tailoring of the warranty is essential. For example, Air Force managers noted only missile and engine warranties could be effectively tracked using data systems specifically designed for that purpose. However, they noted there is still much to be done for other types of weapon systems. (10) The need for tailoring occurs due to different missions and varying levels of operational use. Some weapons are used frequently such as aircraft whereas a missile is normally used only once. Use of quantitative tools can help with the tailoring process by ensuring an objective analysis of tradeoffs among system parameters. The Air Force Product Performance Agreement Center and The Analytic Sciences Corporation have developed such models. According to <u>Contract Management</u> magazine, the TASC model is referred to as the Warranty Decision Support System (DSS). The DSS has two major modules. The first module assists with the selection of the proper type of warranty for a particular program. The second module contains analytical tools for warranty analysis such as reliability growth analyses and test plan risk models. (11)

- Warranties should be obtained for technical orders where it is cost-effective and practical. (1:246.7-2)

## CONCLUSIONS

The WSWA works best if a contractor is truly motivated and contractually incentivized to improve a weapon system reliability and maintainability with a warranty. The all-too-common approach is to punish a contractor for defects rather than provide a reward for good performance. Astute defense contractors will market their weapon systems based on their ability to comply with WSWA requirements.

It is still to early too make an overall assessment of the WSWA effectiveness. This will occur after enough historical data on several of the major weapon system effected is analyzed. A key area of long-term WSWA analysis should be its effects on the component breakout philosophy as prime contractors attempt to mitigate their warranty risk with items supplied by subcontractors.

Long-term challenges concerning the WSWA will be to ensure cost-effectiveness, military utility, and meaningful administration occurs. Contract managers have a wide variety of management tools and contractual remedies available to them for developing effective warranties tailored to their specific acquisitions. The key management question is whether the WSWA will improve product quality. The answer depends on such things as the Government's ability to administer and enforce the warranty and proper warranty planning. As a result, strategic acquisition planning is essential to integrate statutory warranty requirements into the particular weapon system's overall design, performance, and supportability baselines.

Effective warranties for major weapon systems are no accident. Rather, they are the result of careful planning and coordination between the system's design and logistics supportability elements. Warranty planning should use a "systems" approach to determine the best overall mix of logistics elements throughout the weapon system's life cycle.

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The opinions expressed in this paper are solely those of the author and should not be interpreted to represent the views of any U.S. Government agency.

Author's Note: Major Lee Daney, USAF and Lieutenant Colonel Joseph Avon, USAF contributed to this paper.

# CREATIVE ANALYSIS - THE SECRET TO WARRANTY COMPLIANCE

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## ABSTRACT

Performance warranties for weapon systems have now been required by law since 1985. Since 1982, when the authors established TASC's Warranty Analysis/Applications Center (WA/AC), they have done a variety of warranty analyses. Those analyses have differed not only by program, but by program phase and perspective (buyer or seller) as well. The design and conduct of warranty analysis is therefore more art than algorithm.

This paper presents a sampling of the authors' experience in conducting several dozen warranty analyses for Government and industry program offices. Each analysis has been unique, requiring different blends of staff talent and techniques. This paper describes how these resources have been applied to warranty analyses for systems in various phases of the acquisition process.

## INTRODUCTION

The availability of warranties on virtually every item of consumer goods has made them a familiar part of everyone's life. That familiarity, however, has bred a certain amount of distrust as automobiles or television sets seem to malfunction just after the warranty period has expired. Some doubters believe that consumer goods makers have so completely mastered their product that its useful life is just slightly longer than the warranty period.

Given the foregoing pessimism, it is probably understandable that the recent legislative requirement to obtain weapon system warranties was cautiously received. Despite a relatively long-term, and successful, use of warranties and guarantees within the Department of Defense (DoD), there are those who believe they cost too much, are too much trouble, and they don't work. The purpose of this paper is to show how artful analysis can increase the likelihood that an effective warranty will be in place with the system reaches the field.

## PROBLEM

It is the policy of the Department of Defense (DoD) that only cost-effective Weapon System Warranties will be obtained. That policy has recently been promulgated in service regulations, e.g., AFR 70–11 (Ref. 1). At the time that AFR 800–47 was in coordination enroute to becoming AFR 70-11, a General Accounting Office (GAO) study, *DoD Warranties. Improvements Needed in Implementation of Warranty Legislation*, July 1987 (Ref. 2), found that cost-benefit analyses (CBAs) were performed for only 9 of 97 warranties reviewed. Our position is that CBAs *must* be done to either advocate a warranty or to support a request for waiver from the warranty requirement.

CBAs are difficult to do, in part because they overlap other analyses but also because pertinent cost elements vary by warranty type. For example, engineering/reliability analysis will normally be required to bound equipment failure rates that drive risk and cost. Furthermore, pertinent cost elements are not the same for all types of warranties. Figure 1 shows how the dominant elements within TASC's Warranty Cost-Benefit Analysis Model vary by warranty type. These costs are rolled up into a total cost projected for each given set of input assumptions and values.

| COST ELEMENT | RIW | REA | LSC | AG CCR CRG EW MTB RG | MPC | IA | CLR | CSL ULG | MDG | COD | SVG |
|---|---|---|---|---|---|---|---|---|---|---|---|
| INVESTMENT | x | x | x | x | x | x | x | x | x | x | x |
| Government Program Management | | | | | | | | | | | |
| Prime Equipment Acquisition | | | | | | | | | | | |
| Production Hardware | | | | | | | | | | | |
| Production Spt. and Svc | | | | | | | | | | | |
| Production Test and Eval | | | | | | | | | | | |
| Initial Transport | | | | | | | | | | | |
| System Installation | | | | | | | | | | | |
| System Provisioning/Modif | | | | | | | | | | | |
| Installation Kit Spares | x | x | | | | | | | | | |
| Support Equipment | x | x | | | | | | | | | |
| Hardware Acquisition | x | x | | | | | | | | | |
| Initial Spares | x | x | x | x | x | | | | | | |
| Initial Support Acquisition | x | x | x | x | x | | | | | | |
| Initial Spares (Hardware) | x | x | x | x | | | | | | | |
| Software Investment | x | x | | | | | | | | | |
| New Item Entry | x | x | | | | | | | | | |
| Facilities | x | x | | | | | | | | | |
| Documentation | x | | | | | | | | | | |
| Initial Training | x | x | x | x | x | x | x | x | x | x | x |
| Product Performance Agreement | | | | | | | | | | | |
| OPERATIONS AND SUPPORT | x | x | x | x | x | x | x | x | x | x | |
| Corrective Maintenance | x | x | x | x | x | x | x | x | x | x | |
| Below Depot Level | x | x | x | x | x | x | x | x | x | x | |
| Depot Level | x | | x | x | x | x | | | | | |
| Scheduled Maintenance | x | | x | x | x | x | | | | | |
| Labor | x | | x | x | x | x | | | | | |
| Materials | x | x | x | x | x | x | x | x | | x | |
| Packaging and Shipping | x | x | x | x | x | x | | | x | | x |
| Software Maintenance | x | x | x | x | x | x | x | | | | |
| Inventory Storage | x | x | x | x | | | | | x | | |
| SE Maintenance | x | x | | | | | | | | | |
| Documentation Maintenance | x | x | x | x | x | x | x | x | | | |
| Sustaining Supply Support | x | x | x | x | x | x | x | x | | | |
| Replenishment Spares | x | x | x | x | x | x | x | x | | | |
| Supply Systems Management | x | | x | | | | | | | | |
| Recurring Training | | | | | | | | | | | |

Legend

| | | | |
|---|---|---|---|
| AG | Availability Guarantee | LSC | Logistics Support Cost Guarantee |
| CCR | Captive Carry Reliability Guarantee | MDG | Mission Dependability Guarantee |
| CRG | Component Reliability Guarantee | MPC | Maximum Parts Cost Guarantee |
| CLR | Chronic LRU Guarantee | MTB | MTBF-Verification Test |
| COD | Correction of Deficiencies | REA | Repair/Exchange Agreement |
| CSL | Commercial Service Life Guarantee | RG | Reliability Guarantee |
| EW | Engine Warranty | RIW | Reliability Improvement Warranty |
| IA | Incentive Award | SVG | Storage Verification Guarantee |
| | | ULG | Ultimate Life Guarantee |

Figure 1 Cost Element/Warranty Matrix

Experience shows that several iterations of the analysis process are required in order to build a credible cost-benefits analysis. An important conclusion we have come to is that this analysis is more art than science, especially since the analyses vary according to acquisition phase, available data, and consumer/producer perspectives.

## RESOURCES

In establishing our warranty analysis capability, we developed the following resources:

(1) A Warranty Analysis/Applications Center (WA/AC), a corporate center of excellence and warranty data,

(2) A sophisticated series of analytic tools that support quantitative warranty analysis, and

(3) A skilled and experienced staff of warranty practitioners who employ the data and analytic tools to create imaginative and effective warranties.

The tools have been aggregated within an automated Warranty Analysis Decision Support System (DSS) to assist the analyst in doing research, gathering data, selecting a warranty type, and accomplishing quantitative analysis.

Research and data collection can be conducted through a computer-based process applied to all the data and information stored in the WA/AC and organized into an automated database.

Warranty selection, i.e., the matching of warranty-peculiar attributes to program-specific requirements, is achieved through a knowledge-based software program that identifies a likely solution and one or two alternatives. These choices are the alternatives for the cost-benefit and other analyses that must be accomplished before a warranty can be placed on contract.

At the heart of our warranty analysis activity is the number-crunching Computational Analysis Module (CAM), shown in Figure 2. Since one of the analyst's primary responsibilities is to provide insight into warranty cost-effectiveness, a Cost-Benefit model was designed to provide pertinent figures of merit. These data can be put out in formats to suit the military services or DoD's Cost Analysis Improvement Group (CAIG).

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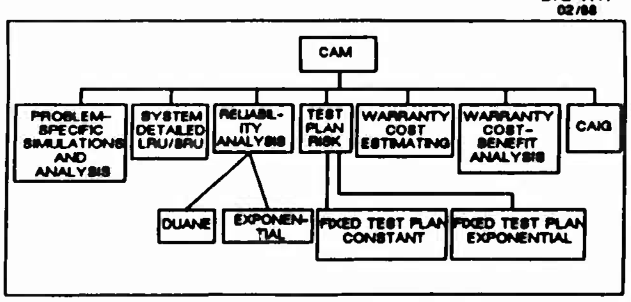


Figure 2 Computational Analysis Module

The analysis tools are structured not only to stimulate the analyst's involvement, but to require it. At TASC, our skilled and experienced staff of warranty analysts are the "third leg" of our resources triad. They are by far the most important leg, as we have experienced that quality warranty analysis requires considerable creativity in devising and conducting the analysis, and at least as much skill in interpreting and communicating the results.

## TECHNIQUES

Each warranty project contains its own unique characteristics, requiring unique solutions. Those solutions, though, are spawned from a mainstream warranty decision support process that TASC has evolved since the early 1970s. We have enhanced the basic process into an expert system-based Warranty Analysis Decision Support System, which we have used successfully on several dozen DoD projects (Ref. 3). Achieving such success required numerous excursions from the mainstream process by creative human analysts. The automated DSS provides warranty approaches and sophisticated computational capability, but the tailoring of the analysis process to individual warranty problems and the evaluation and interpretation of analysis results will always be the domain of skilled analysts.

### *Warranty Problem-Solving*

Shown in Figure 3 is the mainstream warranty Decision Support Process and its *approximate* correspondence to standard problem-solving phases.

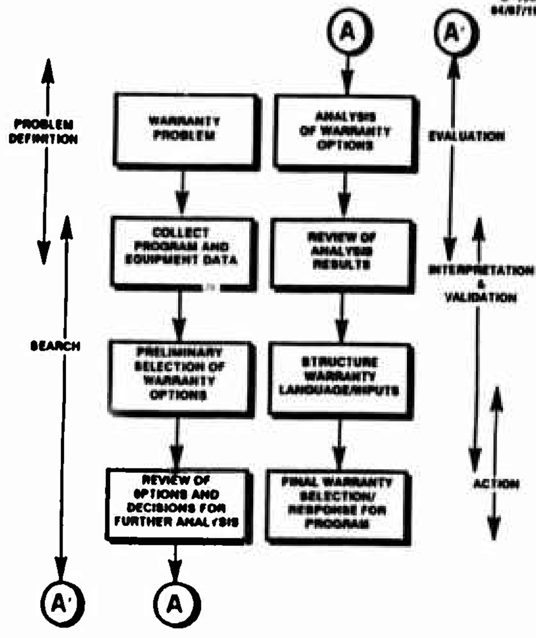


Figure 3 Warranty Decision Support Process

The warranty process can begin with the recognition by a Government program manager that warranty is required for compliance with current policy, and that full justification will be required whether his decision is to have or not to have a warranty applied to his program. A similar problem confronts the industry program manager responding to a Government RFP, or initiating a warranty proposal from scratch. Either situation must be eventually transformed to an objective (problem) that a potential warranty must accomplish (solve). The warranty Decision Support Process then proceeds as shown in the figure. Although not shown in Figure 3, iterations to previous phases, in the face of new or changed information, are almost always necessary.

*TASC Warranty Decision Support Process*

TASC's Warranty Analysis Decision Support System embodies the process depicted above. The DSS is comprised of four subsystems (TUTORIAL, LIBRARY, ANALYSIS, TAILORING). The heart of the DSS is the ANALYSIS subsystem, made up of the Warranty Selection Criteria Module (WSCM) and the Computational Analysis Module (CAM). (While the earliest version of the DSS was developed with Air Force sponsorship, TASC has independently enhanced the system far beyond the original capability.)

The WSCM leads the user, employing a series of questions and prompts, through a maze of warranty choices. The outcome is a very small (one or two) set of potential warranty types, downselected from all known types of warranties. The WSCM is typically employed by program analysts to converge on the type of warranty that best fits their program.

The Computational Analysis Module (CAM) complements the WSCM by providing a host of tools that can be used to analyze the WSCM "recommendations," or to conduct *any* warranty analysis. Results from these models can then be operated on by the Warranty Cost-Benefit Analysis model to provide CBA figures of merit—a good analysis strategy, even if it were not required by DoD policy.

A unique characteristic of the DSS is the software submodule (Figure 2) labeled "Problem-Specific Simulations and Analysis." It provides the opportunity to the artful analyst to *tailor the analysis process* to the warranty-related problem at hand.

The tools within the CAM, particularly the Problem-Specific Simulations and Analysis submodule, provide the capability to conduct analyses across disciplines as diverse as essential performance requirements analysis, dormancy degradation, risk and pricing analysis, and "Bayesian statistics" analyses. Thus, TASC has defined a Warranty Analysis Decision Support System, and assembled the appropriate tools into a computerized Warranty Analysis Decision Support System. The DSS has proven to be a powerful asset for creating effective solutions to the whole spectrum of warranty-related problems.

*Tailoring The Analysis Process*

The process described above in its computerized form can lead to adequate solutions to straightforward warranty problems such as:

1) What kind of warranty is appropriate for an avionics upgrade system, to be produced in large quantities and operated many hours? Large amounts of field data show the predecessor system to have experienced barely adequate performance compared to similar systems.

or

2) The law stipulates that an "essential performance" warranty is required for systems such as "this one." The contractor will guarantee "required" system MTBF (Mean Time Between Failures) over X months at a cost of Y dollars.

In such uncomplicated examples, the solutions can be readily identified, and then authenticated with a pass through the computerized Warranty Selection Criteria Module. Our experience, however, over the course of several dozen warranty projects, is that it takes significant effort in both data/information-gathering and analysis and customer dialogue, in order to *carefully define* the specific warranty-related problem.

That warranty-related problem can vary considerably, depending where in the system life cycle the need for "doing something about the warranty" is recognized. The recently-issued Air Force Regulation 70-11, *Weapon System Warranties* (Ref. 1), provides guidance on warranty activities by acquisition phase. During the concept demonstration/validation phase, for example, the System Program Office (SPO) should be determining whether or not a warranty is applicable, initiating warranty planning, and conducting a preliminary cost benefits analysis.

Part of the problem at this stage is to determine which *performance requirements* are *essential*, and then which of these essential performance requirements (EPRs) are candidates around which to build a warranty. TASC has defined a detailed step-by-step process for selecting EPRs (Refs. 4 and 5), and Figures 4 and 5 illustrate the very first steps in that process.

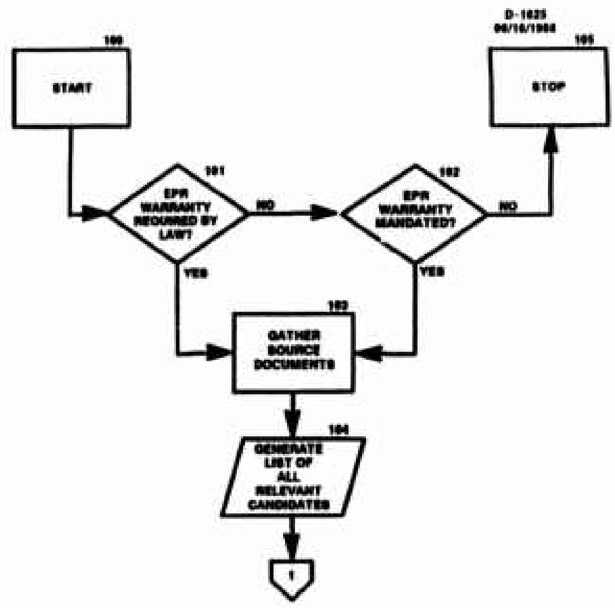


Figure 4 Determining Necessity

On one of our warranty projects, the Government SPO had already identified reliability as an EPR. In the next section, we describe our analysis that led to a preliminary recommendation of a Reliability Guarantee (one type of WSW) for the PAVE MINT and AN/ALQ-172 electronic warfare system upgrades for B-52s.

AFR 70-11 recommends that the WSW plan be fully coordinated and that the CBA be updated during FSD (between Milestones II and III). The Advanced Cruise Missile SPO, late in FSD, found itself needing a warranty approach and the supporting CBA, upon warranty law enactment. Since neither preliminary warranty plans nor CBA existed, TASC developed the baseline warranty approach and CBA. An advantage to being well along in FSD was that some FSD-type information (such as PRAT results, ORLA data, repair costs, etc.) was available. In the next paragraph, we describe the art applied in structuring

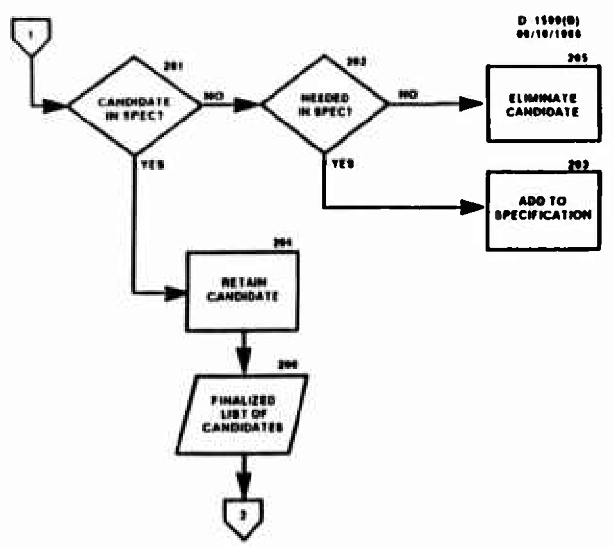


Figure 5 Screen for Contractor Control (Perform for *each* candidate)

and performing the analysis. Typically, artful analysis precipitates other interesting questions: in this case, one was "What kind of aging and surveillance program is necessary to assure that a dormant cruise missile system will effectively perform its assigned strategic missions?"

Prior to award of the production contract (Milestone III), AFR 70-11 recommends that the CBA again be updated and that the WSW be included in the production contract. Alternatively, the program office may request a WSW waiver if such request can be justified. The Army AQUILA program, preparing for Milestone III in 1986, had tailored an "expected failure" warranty for the production contract. When analyzed from the *producer's perspective* the proposed warranty was found to be *very risky*. The second example in the next section provides more details.

The problems requiring resolution under the guise of warranty are virtually unlimited, and as mentioned earlier, each of our several dozen warranty analysis support efforts has been unique. The makeup of the analysis team must change to fit the problem and, indeed, we have tapped virtually all the same talents from TASC's technical staff that one would find in a Government or contractor major weapon system program office.

*Manipulating and Complementing the Models*

Earlier, we enumerated some of the DSS tools and the analyses that they facilitate. In the paragraphs immediately preceding, the importance of redefining warranty-related problems as necessary, and of identifying and applying the proper blend of professional talents was stressed. We have experienced that the process of *artful problem-solving* by these mutli-disciplined teams always dictates the creation and use of ad hoc, problem-peculiar tools.

Example areas of analysis that have required the building of problem-peculiar models are data fusion, information enhancement, Bayesian techniques, projection of monetary risk, and tangible and intangible benefits.

Figure 6 diagrams a tailored warranty analysis flow process that we conceived and implemented for the ACM project mentioned earlier. The missile is almost always dormant during deployment, but is subjected to periodic tests of varying effectivity. At the time of the warranty analysis, performance data was sparse, consisting of some fragmented PRAT (Production Reliability Acceptance Testing) and DT&E (Development Test and Evaluation) results.

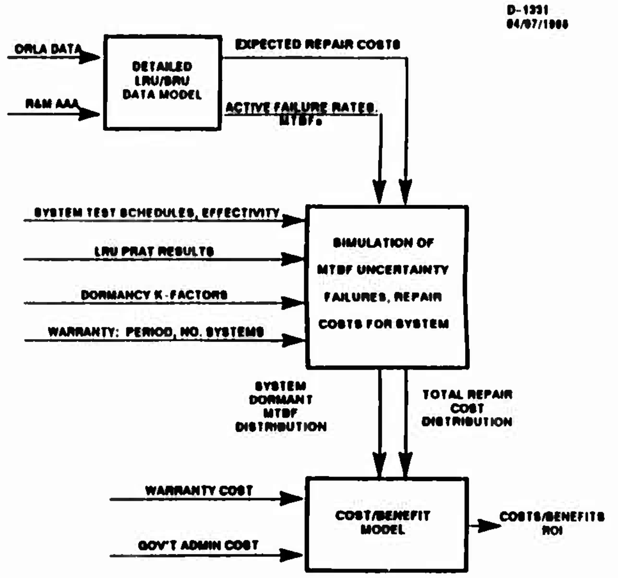


Figure 6 Advanced Cruise Missile (ACM) Warranty Analysis Flow Process

While the original problem seemed to be, "Provide a warranty that satisfies the requirements of the law," the real problem evolved into determining whether or not *any* warranty approach would be cost-beneficial. That, in turn, required synthesis of available test data and using Bayesian techniques to extract *every bit* of information inherent in that data. Those techniques, combined with others, ultimately led to "system" dormant MTBF and total repair cost distributions that were not of closed form but which were central to the analysis of costs, benefits, and return on warranty investment.

This excursion into the realms of data fusion, information extraction and enhancement, alternate mathematical formulation, and simulation is a typical example of how available tools must be complemented with other methods to suit the problem at hand. Further, it underscores the creativity required to:

(1) Sense when problems must be decomposed, expanded, and/or redefined,

(2) alter the applications and sequences of existing models to fit the problem, and

(3) build and execute new models whenever necessary and integrate all results into a cohesive analysis of the real problem.

After tailoring the analysis to fit the particular warranty problem, interpreting analysis results and formulating recommendations for program management action are important last steps in the decision support process. These steps also demand cautious creativity: cautious so as not to introduce bias, and creativeness in the sense of ensuring that the uncertainty surrounding the warranty decision is properly reflected. The next section provides two more examples of how this concept of art in analysis was used.

## EXAMPLES

### *PAVE MINT and AN/ALQ-172*

These systems are electronic warfare system upgrades for B-52Gs and Hs. At first the Air Force program office requested a warranty approach that would meet the requirements of the law A more fundamental question, however, revolved about whether or not the Air Force really needed a warranty, and how much should it be willing to pay—an activity typically accomplished between Milestones I and II. Since the upgrades were *reliability upgrades*, system reliability was the EPR around which the SPO desired to build a warranty approach.

Discussions with the Air Force and contractor program offices revealed that final system configurations would vary by aircraft series and be a mix of existing LRUs (Line Replaceable Units), modified LRUs, and new LRUs. Eventually, we verified that the Air Force was concerned about operational MTBFs, and wanted to

(1) Assess the probability that laboratory and field MTBFs would meet or exceed MTBF values specified for the PAVE MINT and ALQ-172 systems,

(2) Determine the applicability of a warranty incentive approach, and

(3) Receive a recommended course of action on warranties (Ref. 6).

It is extremely important, from the analyst's perspective, to realize that the three problems stated above are definitely related to, but quite different from "providing a warranty approach that meets the requirements of the law." Analyzing the problems required

(1) A comprehensive field reliability baseline of the existing systems and their constituent LRUs,

(2) Engineering and risk analyses of proposed new designs and projected effects on future system configurations,

(3) Repair cost analysis on existing and projected future systems and LRUs,

(4) Assessments of field performance compared to laboratory testing results for similar systems, and

(5) A recommendation on warranties, based on projected field performance;

whereas, "providing a warranty approach that meets the requirements of the law" was done practically by inspection, with the team settling on a Reliability Guarantee approach.

Reliability risk, life-cycle cost, and cost-benefit analyses provided the output to construct the decision support curves shown in Figure 7. The curves display net savings to the Government if the contractor were to provide a Reliability Guarantee for five of the riskiest system LRUs at various percentages of unit production cost for each year of the guarantee period. The savings, of course, depend on what field MTBF would be achieved by the system. If the Government felt that the system MTBF would be $\theta_{PF}$ (Field MTBF predicted by TASC, equal to 47 hours) then it should be willing to pay up to 3+ % for an RG. If the system were only as good as 40% ($\theta_{0.4}$ = 28) of the system specification, then an RG would still be cost-effective at 7%. If, at the other end of the scale, the system specification ($\theta_S$) of 70 hours were met in the field, then an RG would not be cost-effective.

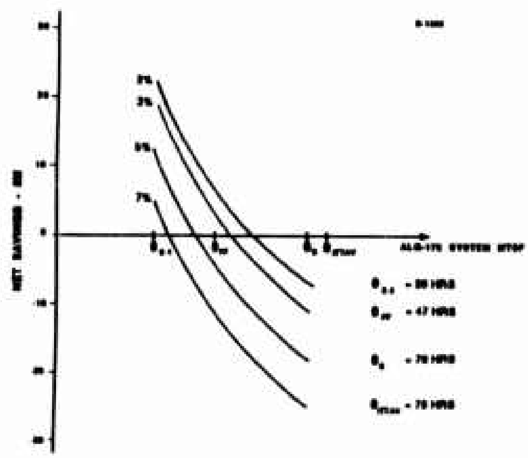

Figure 7 Warranty Decision Support Curve

Thus, the concept of artful analysis provided insight and a range of decision alternatives far beyond simply specifying a Reliability Guarantee to meet the law. In fact, with the analysis results, the Government could easily have justified *not* having a warranty, if it had a reasonable expectation of fielded system MTBF of 55 or more hours, even though the specified MTBF, $\theta_S$, was 70 hours.

### *AQUILA Remotely-Piloted Vehicle (RPV)*

This last example comes from a warranty proejct on the Army's AQUILA program (Ref. 8). The AQUILA is made up of the following major components:

(1) Unmanned Air Vehicle (AV),

(2) Mission Payload Subsystem (MPS),

(3) Command and Data Link,

(4) Onboard Navigation System,

(5) Ground Control Station (GCS),

(6) Ground Data Terminal,

(7) Launch Subsystem (LS), and

(8) Recovery Subsystem (RS).

The system is designed to launch a small RPV and control it via data link on target acquisition, target designation, and aerial reconnaissance missions, and then recover it into a net-like recovery subsystem.

After several years of dialogue between the U.S. Army and the equipment contractor, the Army had specified an "expected-failure" type of warranty for each of five major subsystems. The Army would fund repairs up to the expected number, per individual subsystem, in accordance with the schedule shown in Figure 8.

| Subsystem | Mean Units Between Failures | Utilization Rate | Expected Failures (18 month warranty period) |
|---|---|---|---|
| AV | 59 hours | 43.3 hrs/yr | 1.0 |
| LS | 20 launches | 297.0 launches/yr | 22.0 |
| RS | 25 recoveries | 297.0 recoveries/yr | 18.0 |
| GCS | 120 hours | 868.8 hrs/yr | 11.0 |
| MPS | 25 hours | 43.4 hrs/yr | 3.0 |

Figure 8 AQUILA Expected Failures Warranty Specifics

TASC was under contract to provide warranty cost-benefit analysis to the Army AQUILA program office. At the time, the Army was considering a purchase of 376 AVs, and we shall focus on that for purposes of this discussion. Straightforward calculation indicated that about 414 AV failures could occur, and catastrophic ones could mean replacing the entire RV at a cost of about $1M. A reasonable expectation was that numbers of these magnitudes would be factored into the cost of the warranty to the Government.

Carefully analyzing the warranty language from the *producer's* perspective of *minimum risk exposure*, we found that the Government was obligated to pay for only the first failure on each RPV during the 18-month period. For the RPVs that did not fail at all, there would be no payment, and for those that failed more than once, the contractor would pay, under the terms of the warranty remedies.

Using Poisson process analysis procedures and considering the *number of failures* per Air Vehicle as the random variable, it was readily determined that 125 of the 376 AVs probably would not fail during the warranty period, 138 would fail once, 76 would fail twice, 28 would fail three times and nine would fail four times or more (See Figure 9). The 76 AVs failing twice would produce 152 failures, and the Government would pay for 76 repairs; the 28 AVs failing three times would yield 84 failures, with the Government paying for 28, and so on.

A summary of the scenario is shown in Figure 10. For the expected 414 AV failures, the Government would, under the wording of the warranty clause, fund 252 repairs, and the contractor would be forced to fund 162 repairs--and this is for AVs performing "according to spec" (the nominal "no-risk" situation).

TASC's observation to the Program Office was that the Contractor exposure for repairs of 152 failures constituted a significant risk, and he would therefore be forced to price the cost of performing them into cost elements other than "warranty." Our recommendation was for the Army to recognize the Government's liability for all 414 AV failures and to change the wording of the warranty clause to reflect the Government's original intent to fund expected failures for the *population* of AVs, *and not on a per vehicle basis.*

This example illustrates that creative analysis is as necessary after a warranty clause has been written as it is in the warranty formulation phase, particularly near Milestone III, as the final warranty is firmed up and readied for negotiation. Again, the automated DSS contains the tools necessary to manipulate the

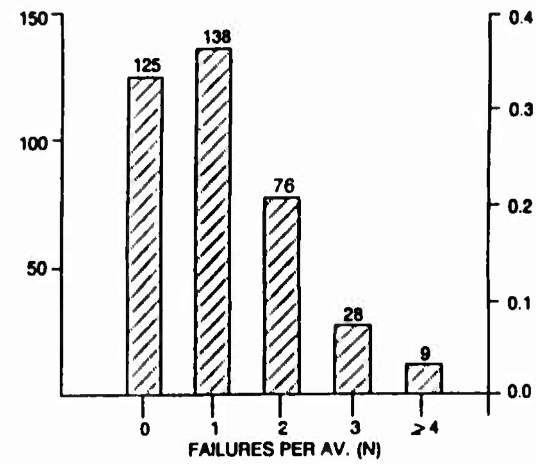


Figure 9 Distribution of Failures Among 376 AVs

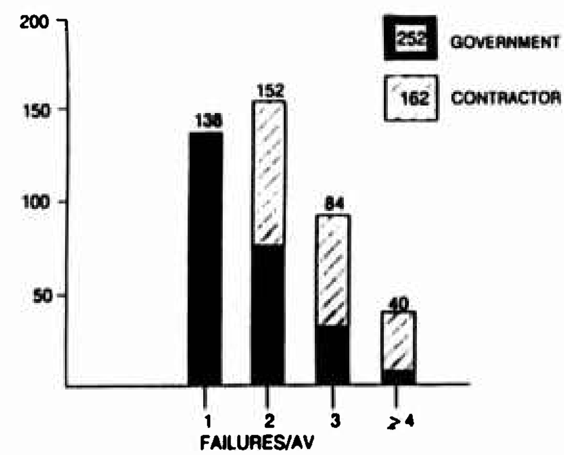


Figure 10 Distribution of Repair Funding Responsibilities

numbers, but problem recognition and resolution clearly resulted from the efforts of resourceful human analysts.

## CONTINUING/FUTURE DEVELOPMENT

The weapon system warranty legislation (10 USC 2403) provisions are stimulating the application of warranties to an ever-increasing population of products. The attendant publicity and discussion that has surrounded the legislation has inspired the use of warranties for procurements not included in the mandatory provisions. As a result, there is a growing challenge to devise more imaginative warranty solutions, and that will always require human participation. A final note is that the CBA must be included in the contract file, whether or not a warranty was implemented.

## SUMMARY

Warranties are now an integral feature of the weapon system acquisition process. Properly used, they can make a significant contribution to the effectiveness of the system they support. However, it could provide extremely costly not to consider the uniqueness of weapon system programs in structuring warranties for them. Few things in the acquisition process are easy and warranties are no exception. They demand intense personal attention and rigorous time-phased analysis as recommended in AFR 70-11. In this paper, we have described how that analysis can provide positive returns for three dissimilar systems. The flexibility of the methodology and the models used, combined with the skills of the analyst, make that possible.

It is important to remember that the purpose of WSWs is to motivate the producer to attain, sustain, or improve weapon system performance while reducing life-cycle cost. Clearly, that is a worthwhile purpose; however, someone--the producer or the Government--must determine the value/cost attached to the motivation and he potential for payback. A proven approach has been presented here and we encourage all parties in the weapon system acquisition process to give it a test.

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# TOTAL QUALITY MANAGEMENT

# AN EXECUTIVE QUALITY MANAGEMENT ACTION MODEL

FORREST GALE
DEFENSE SYSTEMS MANAGEMENT COLLEGE

## ABSTRACT

Total Quality Management (TQM) is currently receiving substantive emphasis throughout DoD and the Services. A basic tenet of quality management is that the quality transformation of an organization must begin at the top of an organization, i.e., the leadership of an organization must be both committed to and involved in the transformation. To this end hundreds of DoD and Service top executives have participated in a landmark series of executive workshops and produced a substantial body of executive quality leadership/planning work. This paper reports on that work, summarizes the results of the research data collected at the workshops, and based upon the data theorizes and derives the structure of a generic quality management action model. The attributes and functioning of this model in the DoD component service organizations is hypothesized

## INTRODUCTION

There is unanimous agreement among quality experts about the importance of leadership in effecting a quality transformation in an organization. It appears that everyone is "for" quality; verbal commitment is easy to obtain. But involvement, which requires the expenditure of that most precious of executive resources, time, is another matter. Leaders who both commit and involve themselves in quality transformations make the difference between success and failure of quality transformations. Ample experiences with quality transformations both within the United States and abroad have demonstrated the inviolability of this principle of leadership quality involvement. Yet, many leaders are reluctant to "get involved" in a quality transformation, for few leaders will actively work in an area they don't fully understand, haven't mastered, cannot defend, etc. Many leaders have thus attempted to delegate responsibility for quality to subordinates, proclaiming support for quality but not involving themselves in the organizational activity associated with quality transformation. This approach can and often does send a signal to the organization: (i.e.) "I will talk quality, but I won't walk it; I, myself, am not sufficiently committed to invest some of my most precious resource, my time." Invariably, this signal is interpreted as a message that quality does not have primacy, that other things are more important--i.e., more deserving of the leader's time. The need then is to reach leaders with the involvement message, and to quickly equip them with an executive tool kit so that they can not only make the decision to be involved, but also actuate that decision with confidence and competence. To this end, the Department of Defense recently designed, developed, and is delivering an Executive Quality workshop to equip its most senior leaders with the tools and awareness needed to successfully initiate and substain an organizational quality transformation through the early, difficult days. This paper is an exposition of the action research concepts realized within the Executive Quality Workshop format.

## EXECUTIVE QUALITY WORKSHOP ARCHITECTURE

The Executive Quality Workshop is designed as a personal process. Processes are a major focus of the perceptual view of reality that gives quality primacy in transformed organizations. Figure #1 is a representation of the workshop process. The basic tenet upon which the design is based is that the greatest barrier to quality transformation is the individual's resistance to change. We are homeostatic beings. Our bodies require a stable environment in order for us to survive, and much of human endeavor (food, housing, government and social institutions, etc) is designed to achieve stability in an unstable environment, so that we might survive. Thus, threats to stability, on an instinctional level, can be equated to threats to survival (i.e., Change equates to instinctual "death".) Thus, it should not surprise us that change in its many forms is resisted by individuals, organizations, governments, and societies. It is as if we create an organization or social institution to stabilize things, so we can "get on" with the business at hand, and then we ask it to change and are surprised that the institutions and its individual components resist change. Rarely do we successfully design change mechanisms into the process of the organization or social/governmental institution.

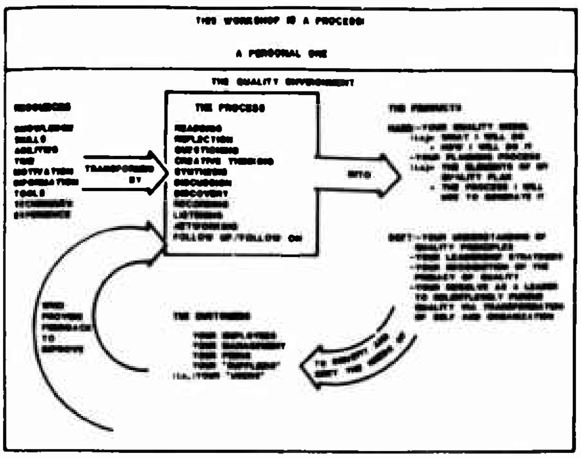
But human beings are adaptable. Within certain biological limits, the human organism is capable of a remarkable range of adaptation. But mind and habit are fixed upon survival, whether physical or psychological, and thus the invariably encountered resistance and the many subtle behavioral manifestations of fear/ anxiety with respect to instinctual/ psychological "survival."

So, though we desire organizational transformation, we need to work, initially at the individual level, and at the top of the organization. After all, when the lights are turned out in the workplace each evening and everyone goes home, what is left? Brick, mortar, machines, physical objects. The real organization is nothing but people. We all know this, but how easy it is to act as if we don't. W. Edwards Deming, the 500 Pound Giant of Quality, has said that, "People are the ultimate resource." If a perceptual shift in how reality is viewed is effected at the top of the organization and cascades down like a waterfall, to all levels of a modern organization, then the transformation to a quality organization will be, over time, a demonstration of each individual's accommodation to change. However, the way in which individual transformation is linked to the transformation of others in the organization (and to the goal, objectives, and raison d'etre of the organizational entity) can only be defined through the architecture of linked teams.

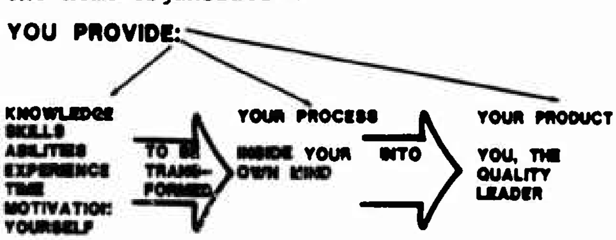
In summary, the organizational transformation process must begin with the leader at the top, and proceed down the hierarchy until all managers and leaders are involved. Next, all employees must be given responsible individual charge, and be organized, through the linked--teaming approach--to address organizational processes. The Executive Quality workshop design recognizes the primacy of the individual transformation, focuses on what is required "at the top" of the organization to initiate and sustain the transformation environment and motive force for change. The design also recognizes--through a small team work environment implemented in the workshop design--the linked team mechanism as the principal architecture for implementation of quality transformation initiatives.

The Executive Quality workshop sequence is designed to flow as the model of figure #1 flows. The first day is given over to resourcing the participating executives. The internal transformation process of the individual is controlled through a series of perceptual devices to sustain interest and shift the leaders environmental window. Industry, defense industry, government/DoD and military service experience are presented and contrasted, and quality transformation principles extracted.

The second day of the workshop is devoted to small executive team activity designed to produce two hard products which executives take away with them: (1) A quality leadership attributes model; and (2) a personal Quality Leadership Plan for executive action. The teams are facilitated by the workshop lecturers. The products are briefed out in a plenary session, and questions and major issues discussed and clarified in a summary panel session led by workshop faculty. Figure 2 is a diagram showing the internal (personal) process each



executive undergoes in the environment and context of the workshop structure. The bridge between the individual (transformation) process and the workshop process is the small work team. The teams are linked to the goals, objectives, and the architecture of the workshop through the product taskings. Hence, the workshop is by design a microcosm of a larger organization quality transformation that includes: (1) application (resourcing); (2) leader development of a personal quality attributes model and quality action plan; and (3) the communication of the plan and behavioral model to others (peers/subordinates) in the organization. The workshop leader/student thus practices "leading" a quality transformation within a supportive, risk neutral environment, with support provided by experts in the field and other leaders working to the same end. The result has been majority acceptance of the precepts of quality by leaders coupled with the resolve and confidence necessary to work the transformation process upon return to the home organization.




Quality leaders, as they processed resources and prepared to develop, in a small team environment, their personal and team quality leadership models and quality action plans, were enjoined to think about the following elements, and were reassured that if they thought about these elements in an input-output action framework, they would be thinking "quality":

- **RESOURCES**
- **CUSTOMER NEEDS**
- **PRODUCTS**
- **PROCESS, PROCESS, PROCESS**
- **CONTROLLING VARIATION**
- **CUSTOMER SATISFACTION**
- **CONTINUOUS IMPROVEMENT (PROCESS)**
- **LINKAGES (QUALITY TEAMS)**
- **QUALITY ENVIRONMENT**
- **QUALITY ASSESSMENT**
- **PEOPLE, TRAINING, GROWTH, REWARDS.**

**YOU WILL BE THINKING <u>QUALITY</u> !!!**

THE EXECUTIVE QUALITY TOOL KIT

The core of the workshop experience is focused on equipping the executive with tools that can be easily understood, readily committed to memory, and referenced as the executive works the quality transformation in his organization. Workshop experience with hundreds of executive leaders has confirmed that tools that can be visually represented are better retained, more easily verbalized, and provide a more flexible base upon which to communicate than verbal tools. Central to the most functional actuation of quality leadership is what has come to be called the Generic Quality

Model. This model (Figure 3) represents, in simple easily internalized visual terms, the basic quality dynamic. Other items in the tool kit include: (a) a quality leadership attributes matrix; (2) a quality action paradigm (the so called "16 steps to quality transformation"); (3) a quality leadership behavior model; and (4) a note on quality leadership that gives examples of the results of applying (3) above.

## THE WORKSHOP TOOLS AND THE EXECUTIVE QUALITY ACTION MODEL

The central focus of the workshop lay in two areas: (1) quality leadership; and (2) quality planning. What follows is a quick look at how these two themes were realized in the workshop process.

### THE LEADERSHIP IMPERATIVE

Quality leadership style, shibboleth, and behavior are central to success. The following style and behavioral model was provided and discussed with executive participants:

SOME QUALITY LEADERSHIP STYLE FACTORS ARE:

- Listening
- Cooperating
- Helping
- Transmitting/communicating
- Creating
- Implementing
- Learning
- Leading
- Following

SOME MYTHS OF LEADERSHIP

- Leadership is a rare skill
- Leaders are born, not made
- Leaders are charismatic
- Leadership exists only at the top of an organization
- Leaders control, direct, prod, manipulate

### THE QUALITY LEADER BEHAVIOR MODEL

| | |
|---|---|
| SUBSTANCE | Helps others achieve needed substance |
| GROWTH | Helps others achieve personal/career growth |
| OPPORTUNITIES | Creates opportunities for others to make uninhabited contribution to the enterprise |
| ENVIRONMENT | Creates an environment conducive to performance |
| EMPOWERMENT | Empowers others |
| OBSTACLES | Removes obstacles to performance |
| DEALS IN SUPPORT | Helps others do what they decide is in their own best interest |
| COACHING/ TRAINING/ EDUCATING | Coaches, trains, educates others |
| COORDINATION | Helps coordinate the work of others |
| MARKETS/OUTLETS | Creates markets and outlets for talents of others |
| RESOURCES OTHERS | Acquires resources others need |
| UNIQUELY EQUIPPED | Is equipped to do that necessary for success which others are not capable of doing |
| STRATEGIES | Generates vision, communication, trust through positioning, and deployment of self |
| PERSISTENT | Tirelessly pursues the mission of the organization through linkage with other leaders on strategic issues |
| ETHICAL, OPEN, HONEST | Maintains a totally open and honest state with others |

### THE QUALITY LEADERSHIP ATTRIBUTE MODEL

Workshop leaders were given the results of research by Bennis and Nanus on the strategies common to all leaders in all walks of life; only four strategies have been found to be utilized by all leaders. Hence, the quality leader must actively pursue these four strategies as he or she works to transform an organization.

**THE FOUR LEADERSHIP STRATEGIES**

- **VISIONING**
- **COMMUNICATION**
- **POSITIONING**
- **DEPLOYMENT OF SELF**

**ALL LEADERS WORK THESE FOUR STRATEGIES.**

A review of the voluminous literature of quality reveals that there are at least 13 distinct dimensions in which actioning to effect a quality transformation takes place. Most all organizational activity focussed on processes, the resources they transform, the products/services they produce, and the customers who use the products/services fall in the following areas:

**ORGANIZATION QUALITY DIMENSIONS**
**- 13 ACTION AREAS -**

| | |
|---|---|
| CONTINUOUS IMPROVEMENT | . CONTINUOUS IMPROVEMENT |
| PURPOSE CONSTANCY | . CONSTANCY OF PURPOSE |
| TOP MGT INVESTMENT | . TOP MANAGEMENT INVESTMENT |
| CUSTOMER FOCUS | . FOCUS ON CUSTOMER NEEDS, WANTS, SATISFACTION |
| PROCESS ANALYSIS/CONTROL | . PROCESS ANALYSIS AND VARIANCE CONTROL |
| CONTINUOUS LEARNING | . CONTINUOUS ORGANIZATIONAL LEARNING/RISK TAKING |
| ALL INVOLVED | . TOTAL ORGANIZATION INVOLVEMENT |
| PERFORMANCE EMPOWERMENT | . PERFORMANCE EMPOWERMENT: EDUCATION, RESOURCES, SELF-IMPROVEMENT OPPORTUNITY |
| RESTRAINT REMOVAL | . RESTRAINT REMOVAL: RULES, REGULATIONS, PROCEDURES, PERSONNEL PROCESSES |
| QUALITY PRIMACY | . CULTURAL CHANGE: QUALITY PRIMACY |
| QUALITY PLANNED/DESIGNED | . PLANNED AND "DESIGNED IN" QUALITY |
| QUALITY CLIMATE | . CLIMATE OF: RESPECT, ETHICS, PRIDE IN WORK, REMOVAL OF SLOGANS, QUOTAS, FEAR |
| CULTURAL SPECIFICITY | . CULTURE-SPECIFIC QUALITY ATTRIBUTES |

AS A LEADER, YOU WILL PURSUE THE FOUR BASIC LEADERSHIP STRATEGIES IN EACH OF THESE ACTION AREAS. WHAT WILL YOU DO TO PURSUE EACH STRATEGY IN EACH ACTION AREA? HOW WILL YOU DO IT? "WHAT" AND "HOW"--WHEN RECORDED AS SINGLE LINE STATEMENTS OF YOUR INTENT--DESCRIBE YOUR QUALITY LEADERSHIP ATTRIBUTES MODEL.

The quality leadership attributes model is a formalized attempt to structure for a leader a model for applying leadership strategies to the 13 quality action dimensions. If one postulates the quality action dimensions arrayed on the X axis of a matrix and the leadership strategies arrayed on the Y axis of the same matrix, then one has a 25 cell matrix. (i.e.)--for the X axis:

**QUALITY LEADERSHIP ATTRIBUTES MODEL**

X AXIS: **THE DIMENSIONS**

- **CONTINUOUS IMPROVEMENT**
- **PURPOSE CONSTANCY**
- **TOP MGT INVESTMENT**
- **CUSTOMER FOCUS**
- **PROCESS ANALYSIS/CONTROL**
- **CONTINUOUS LEARNING**
- **TOTAL ORGANIZATIONAL INVOLVEMENT**
- **PERFORMANCE IMPROVEMENT: EDUCATION, RESOURCES, SELF IMPROVEMENT OPPORTUNITY**
- **RESTRAINT REMOVAL: RULES, REGULATIONS, PROCEDURES**
- **CULTURAL CHANGE: QUALITY PRIMACY**
- **PLANNED AND "DESIGNED IN" QUALITY**
- **QUALITY CLIMATE: RESPECT, ETHICS, PRIDE, REMOVAL OF SLOGANS, QUOTAS, FEAR**
- **CULTURAL SPECIFICITY**

And, for the Y axis:

**QUALITY LEADERSHIP ATTRIBUTES MODEL**

Y AXIS: **THE STRATEGIES**

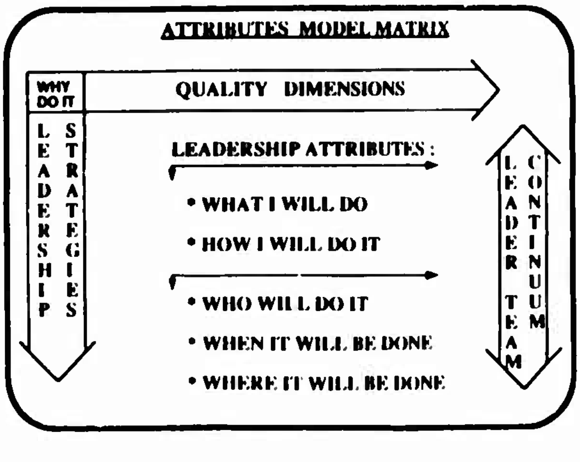
- **VISIONING**
- **COMMUNICATING**
- **POSITIONING**
- **DEPLOYING SELF**

Each leader attending the Executive Workshop was asked to "action" the matrix as a homework assignment, saying "what" he/she will do to action quality to each cell of the matrix, and "how" he/she will do it; i.e., the following paradigm was introduced:

**QUALITY LEADERSHIP ATTRIBUTES MODEL**

- **CREATE 52 ELEMENT MATRIX**
- **EMPLOY EACH STRATEGY IN EACH DIMENSION**
- **SAY "WHAT I WILL DO," "HOW I WILL DO IT"**
- **USE SEVERAL BULLETIZED STATEMENTS FOR EACH CELL**
- **THIS IS YOUR PERSONAL QUALITY LEADERSHIP MODEL**
- **SHARE THIS WITH YOUR TEAM TO ARRIVE AT A TEAM GENERIC MODEL**

The result of this assignment, worked individually as an overnight homework assignment, was the personal action model pictured below with the first two elements ("what" and "how") filled out for the 52 cell matrix. Single line bulletized statements were requested, as a deep application of this tool would take more than one evening. Workshop participants then shared their individual models in a small work team environment the next morning and the team developed a composite model of what "all" quality leaders should do to "action" quality, and how they should do it. The composite models were presented by each team in a plenary afternoon session.



The following thoughts are a summary of workshop participant's thoughts on Quality Leadership in all organizational environments, no matter whether the product is hard goods, or services.

A NOTE ON QUALITY LEADERSHIP

Being a quality leader means:

. Taking personal responsibility for quality.

. Insisting that process design take place concurrently with product design.

. Insisting that processes are adequately resourced (people, equipment, processes, material, training, etc).

. Insisting that proper time is allotted for quality training and process education.

. Giving workers responsibility for quality and allowing shutdown by individuals who discover a quality problem.

. Insisting that scientific methods such as the Taguchi methodology are used to guide the design of processes.

. Heavily utilizing statistical process control to ensure processes are in control and stay in control.

. Working closely with other management peers to ensure the highest quality.

. Never knowingly allowing bad or marginal products to be shipped to a customer.

. Seeking information from customers, to assure that no "silent defects" are present in products.

. Fully informing all personnel of the details of the performance of the operation and the company as a whole.

. Insisting that production strategy and quality strategy form the centerpiece of corporate/organizational competitive strategy.

. Insisting that the workforce participate in an organization-wide quality transformation.

. Following, to the fullest extent possible, the 14 points of Edward Deming.

. Being frequently visible in the office/factory floor and spending a significant amount of time working quality issues with PAT teams and QRBs.

. Continuously working to create a climate of trust and responsibility in the office and in the production management suite.

. Remaining fully informed of the latest techniques, tools, and technology, and looking for opportunities to apply same and innovate.

. Working with shop-stewards and other union personnel to create a respectful partnership and to ensure that everyone remains fully cognizant of the competitive situation in the competitive marketplace.

. Creating, maintaining, and working to an organization master plan that includes modernization initiatives.

. Continuously working to increase the flexibility and decrease the time-to-market influence of the production operation.

. Creating ties between the local community and the production operation such that a continuous supply of the best of local labor and professional resources are available to the organization.

. Creating a career development and continuous workforce training program to increase workforce competence and provide incentives to facilitate retention of the best and brightest in the workforce.

. Facilitating a climate of respect for the individual and fostering pride of workmanship and professionalism.

THE QUALITY LEADERSHIP ACTION PLAN

The "what" and "how" of the plan having been worked on in a personal and generic (team) basis, the task of fleshing out a personal and also group (generic) plan on the "when, where, and who" of the Organization led was next worked. Leaders were asked to work the final three elements as a homework assignment in the 52 activity cells suggested by the leadership attributes matrix (i.e., for each strategy and dimension, when, where, and who will work the transformation?) The Plan Paradigm is outlined below:

## QUALITY LEADERSHIP PLAN

- WRITE SIMPLE PLAN
- USE "16 STEPS TO QUALITY" AS GUIDE
- USE QUALITY PLANNING SEQUENCE AS GUIDE
- USE BULLETIZED STATEMENTS
- STATE "WHO, WHEN, WHERE" FOR EACH STEP
- SHARE WITH YOUR GROUP TO DEVELOP A GENERIC CONCEPTUAL PLAN

THE 16 STEPS TO QUALITY TRANSFORMATION

These 16 steps are the basic steps to quality planning and actioning for a leader. The questions that attend each step when answered fully, provide a planning framework for any organization.

## 16 STEPS TO QUALITY TRANSFORMATION

- Identify/describe mission
- Identify/describe customers
- Identify/describe customer needs/wants
- Identify/describe organization "products"
- Identify/describe resources
- Identify/describe transformation process
  - Tasks, activities, procedures, sequences
  - Environment/controls (rules, regs, laws)
- . Identify/describe elements of process
- Identify/describe quality elements of process
- Identify/describe process-product "cause-effects"
- Identify/describe priorities of elements and factors
- Identify/describe controllables and uncontrollables
- Identify/describe limits necessary to control
- Identify/describe process measurements
- Generate plan; implement; monitor
- Identify/describe continuous improvement strategy
- Continuously check implementation using "customer satisfaction" measure

The following questions apply to each of the "16 steps" as indicated:

**QUESTIONS FOR A QUALITY LEADER**

| | |
|---|---|
| Mission Goals Objectives | What is my mission? Goals? Objectives? What are my organization's Mission? Goals? Objectives? |
| My Customers | Who are my immediate customers? My ultimate customers? |
| Organization Customer | Who are my organization's immediate customers? My organization's ultimate customers? |
| Customer Needs | What are their needs? Their wants? Short term? Mid term? Long term? How do I know? |
| My Organization/ Products/Services | What are my products/services? What are my organization's products/services? How are they interrelated? How do I know? |
| Product/Service Quality Factors | What are the quality factors of each of my products/services? My organization's products/services? How are they interrelated? How do I know? |
| Resources | What are my resources? My organization's resources? |
| Transformation Process Delineation | What are the processes by which I transform my resources into my products/services? What are the processes by which my organization effects the transformation of individual products/services and resources into organizational products/services? How are they interrelated? How do I know? |
| Process Quality Elements | What are the quality elements of my transformation processes that influence my products/services quality factors? What are the organizational process quality elements? How are they interrelated? How do I know? |
| Cause-Effect Quality Priorities | What are the relative priorities of my quality elements and the nature of their interrelationship? Of my organization's process quality elements? Their interrelationships? How do I know? |
| Quality Element Control | Which of my quality elements are controllable? Which of my organization's quality elements are controllable? How can they be controlled? How do I know? |
| Control Parameter Identification | What are the quality element parameter combinations (Quantitative or qualitative) which will result in control of my/my organization's product/service quality? |
| Control Parameter Measurement/ Assessment Observation | How will I/we measure/access or observe the control parameter sets? How often? |
| Continuous Process Improvement | How can my own transformation processes be improved/redesigned to increase quality? My organization's transformation processes? How do I know? |
| Continuous Resource Improvement | How can my resources be improved to increase quality? My organization's resources? How do I know? |
| Quality Environment Check | Is my/my organization quality environment changing? (i.e., customer wants, needs, competition, etc.) If so am I accommodating the change in my transformation process? How do I know? |
| Quality F ure Planning | What is my vision of the quality future? Am I planning to change resources, transformation process, product/services to meet the quality requirements of the future? |
| Quality Future Actions | What actions are necessary now to evolve resources, transformation process, products/services to meet the projected future quality requirements? |
| Ultimate Quality Check | A e my customers/users satisfied? Are product/service needs and wants met? Is the same true for organization's customers/users? How do I know? What changes improvements do they suggest? |

## ENVIRONMENTAL SCAN

The 16 step architecture is often preceded by an environmental scan in many organizations, a kind of snapshot of the Quality Environment as it "exists". When the scan is applied by the leadership of the organization, a leadership gestalt is achieved. Leaders in the workshop were asked to attempt a scan prior to workshop attendance in accordance with the after-the-workshop paradigm they were given below:

**A QUALITY ACTION PARADIGM**

1. Do an environmental quality scan (identify the current "Barriers to Quality")
2. Answer the "16 Steps to Quality Transformation" questions
3. Develop a quality plan using a team approach (we will do this in the quality workshop)
4. Execute your quality plan, adhering to TQM principles while doing so.
5. Monitor progress and outcomes (product quality, environment, customer satisfaction, process elements, etc.)
6. Adjust process elements, resources, environment, as necessary to continuously improve process

The scan questions are designed to determine the perceptual barriers to quality transformation that may exist in the mind of <u>the leader</u> that must be resolved prior to entering into a quality transformation activity, i.e.:

**THE ENVIRONMENTAL QUALITY SCAN**
**ACTION PARADIGM STEP #1**

**<u>PERCEPTUAL BARRIERS TO QUALITY IMPLEMENTATION</u>**

| | |
|---|---|
| QUALITY DELEGATION | I fully support it; now <u>you</u> do it |
| NOT INVENTED HERE | Not invented here - it won't work here because . . . |
| HARD WORK WILL DO IT | Get to work! Hard work and persistence are all that is needed. |
| FEAR | Fear: If I/we change, Then . . . loss of jobs, turbulence; the stress of the new; extra work; my deficiencies exposed, etc. . . . |
| IT'S COMMON SENSE | So what else is new? Isn't it just good management (or common/uncommon sense)? |
| MY PAY OFF | What's in it for me? |
| THIS, TOO, SHALL PASS | It's just another fad; it will go away like all the others have. |
| ONLY I KNOW HOW | I know my business/job best; no one else can help me to implement it in <u>my</u> organization. |
| I KNOW IT ALL | I already know all there is to know about quality; there's nothing more for me to learn; I'm a professional. |
| SOLELY THE JOB OF WORKERS | It is the workers/subordinates' job. They're the ones that produce the product/service. |
| CANNOT AFFORD IT | We cannot afford to improve it, it costs too much; you never get something for nothing. |
| NOT NEEDED WHY CHANGE? | Improvement is not needed, we do it well enough now. Good ol' MIL-Q-9858A, etc., do the job |
| DOESN'T APPLY | It doesn't apply to my job/organization; I/we don't produce the physical products. We're a service outfit. |
| TAKES TOO LONG | I/we need quick results; improvement efforts take too long |
| I'M TOO BUSY | I'm too busy (being productive) to pay attention to it now |
| BIG EFFORT SMALL PAYOFF | Too much effort for too little reward |
| TOO SOFT AN ISSUE | It's too soft to get your arms around; hazy, diffuse, motherhood. Thus, you can't manage it |
| IT'S BS & HYPE; RHETORIC | It's an empty bag; a slogan, motivation and hype. Where's the beef? <u>Everybody's</u> for quality |
| WORKER MANIPULATION | It's an effort to get more work for less cost; another management manipulation. |
| FAILURE TO UNDERSTAND ISSUE DIMENSIONS | Quality is a quality assurance function. The quality folks will/should handle it. |
| RESISTANCE TO CHANGE | Change is threatening, tiring, resource draining; the results uncertain. Let's make what we now do/have work. If it ain't broke, don't fix it. |
| COST REDUCTION GIMMICK | It's another gimmick to reduce costs and budgets; Here come the cuts |
| RULES & REGS PREVENT | Rules and regulations prevent success ("The System" won't permit me to do it). |
| ANOTHER ENGINEER'S TOOL | It's just statistics applied to production floor processes. That's where it belongs. Quality is an engineer's dream of the perfect world |
| THERE'S NO HOPE | "The system" is too big. My organization's quality effort will get lost in the shuffle or be defeated by "the system." |
| IT GIVES THE WORKERS CONTROLS DANGEROUS | My job is to lead/manage. The basic functions of management haven't changed (i.e., planning, organizing, staffing, directing, <u>controlling</u>). Back to basics! |
| SYSTEM CHANGING TOO FAST (SLOW) | I rotate too fast to make a dent. I won't be able to get agenda continuity with my successor. Things move too slow; I won't see any gains on my watch, so why do it? |
| LOW PRIORITY | With all the things we're charged with leading/managing, this one is way down on the list. |
| WAIT FOR THE MILLENNIUM | We'll eventually (sic) "control" quality almost completely by computer; Why mount a big (costly) "manual" effort now? |

## RESULTS AND CONCLUSIONS

Experienced senior leaders from all the Services and DoD have attended the workshop, applied the instruments/tool kit, and explored the planning and leadership dimension of quality. Many had ongoing quality transformations and a number were experienced quality professionals. None stated any dissonance between actual experience and the Executive Quality management action model presented herein. It must be concluded therefore, that the model has validity and provides a viable framework for leadership action.

**SOME CONCLUDING THOUGHTS ON**

**"QUALITY"**

**"QUALITY IS A NEW WAY OF PERCEIVING REALITY; THIS IS THE CULTURAL TRANSFORMATION."**

**"AS QUALITY LEADERS TRANSFORM ORGANIZATIONS THEY ARE THEMSELVES TRANSFORMED."**

**"THE UNDERSTANDING OF--AND ULTIMATE DEDICATION TO--QUALITY IS ONE OF THE MOST PROFOUND OF HUMAN EXPERIENCES."**

**"THE QUALITY TRANSFORMATION WILL ALWAYS EFFECT THE PRIVATE AS WELL AS PUBLIC LIVES OF THOSE TRANSFORMED."**

**"QUALITY ORGANIZATIONS ARE THOSE WHERE WE ARE CONSTANTLY LEARNING AND GROWING, WHERE RISK-TAKING AND REWARD ARE PRESENT IN ABUNDANCE AND HONORED; WHERE INDIVIDUAL CREATIVITY AND INNOVATION ARE TREASURED; WHERE INDIVIDUAL RESPONSIBILITY FOR QUALITY IS INSISTED UPON AND IS A MATTER OF PRIDE; WHERE IT IS SIMPLY MORE MEANINGFUL, SATISFYING, AND FUN TO WORK."**

# APPLICATION OF TQM CRITICAL PROCESS REVIEW TO THE REQUEST FOR PROPOSAL PROCESS

John Krieger and Charles Duff, HQ Air Force Systems Command

## ABSTRACT

Total Quality Management (TQM) has become the new byword of the Department of Defense. The Department of Defense Total Quality Management Master Plan describes the concept, methodology, and goals of TQM within the DoD. This paper explores the application of the TQM methodology to the Request for Proposal (RFP) process in Air Force Systems Command (AFSC). The RFP process was selected by the AFSC Commander as the first command-wide critical process to be reviewed. The RFP Critical Process Team (CPT) was chartered to review the RFP process, RFP documents, and establish a framework for continual improvement of RFP documents and their preparation process. The paper specifically addresses the establishment of the Critical Process Team (CPT), team training, and the methodology used in the review. It describes establishment of the plan for review of the process, defining the process, involving customers and suppliers, checking the status of the process, analyzing the process for targets of opportunity, and implementation of improvements.

## INTRODUCTION

### TQM in the Department of Defense

Non-production functions such as administrative activities, human resource departments, and accounting departments are often overlooked when an organization decides to improve. Many times, management does not consider these functions because the traditional view focuses on manufacturing processes. "Non-production" is, in fact, a misnomer. All activities produce something whether manufacturing a machined part or an accounting report. If an activity produces something, a process exists, and a process can be improved. (1)

The majority of the "products" developed by the DoD are non-production. Most are paper products in support of developing or ongoing systems, policies, or procedures. The seeming intangibility of these products has caused the corresponding processes to continue virtually without question.

The DoD Total Quality Management Master Plan (unpublished) describes the TQM concept, methodology, and goals. The concept is embodied in the goal of continuous improvement. Ultimately, continuous improvement will become institutionalized. TQM will spread from its origin in the acquisition community to other aspects of the Department and industry.

While many senior managers within DoD have expressed support for TQM, several impediments or constraints exist which could hamper or preclude institutionalization: the potential for lack of constancy of purpose; the perception that TQM doesn't apply to non-production environments; and, the "disease of immediacy". In a bureaucratic environment involving multiple political challenges and changes in the power base, TQM could be reduced to another passing buzzword. Long term commitment is required to sustain the concept.

In an environment of diminishing resources the only alternative is "working smarter". Early experiments within the DoD are yielding encouraging results. The following discussion of the AFSC RFP Critical Process Team is exemplary of actions being taken within Air Force Systems Command to improve the acquisition process.

### TQM in Air Force Systems Command

In a speech to the Association of Old Crows in San Antonio, Texas General Bernard P. Randolph, the AFSC Commander, stated,

> TQM entails an organizational structure that fosters accountability for quality and continuous improvement in products and processes. As a buzzword TQM might change over time; but as a philosophy it will last and is fundamental to Air Force Systems Command. . . .At Systems Command, we're scrubbing every process from the way we issue passes at the front desk to the way we issue requests for proposals. (2)

Command wide TQM projects are selected because they are very painful or have high potential payoffs, they have an effect across the Command, and the Headquarters plays heavily in the process. The first of the Command wide initiatives is the review of the Request for Proposals (RFP) process. It was selected as the first initiative because the CEOs of AFSC's major contractors told the Commander that our RFPs needed improvement. General Randolph states,

> When the government gets an RFP on the street right the first time and companies give their best shot the first time, we'll see shorter, cheaper, cleaner negotiations. We'll see Total Quality Management in the RFP process. That's exactly what a joint AFSC and industry team is aiming at in their current review of the RFP process. (2)

General Randolph appointed Major General David J. Teal, Deputy Chief of Staff Systems, and Brigadier General Kenneth V. Meyer, Deputy Chief of Staff Contracting, as the process owners of the RFP process.

## CRITICAL PROCESS TEAM

The team was selected to provide a cross section of the Command. There are members from the headquarters and each of the five major product divisions. Members were selected to ensure a multidisciplinary approach. Members were selected from contracts, engineering, program management, legal, logistics, comptroller, and product assurance. It was recognized from the outset that the mix of the team was vitally important to the success of the critical process review. Prior studies had concentrated on specific functional areas such as contracting. The RFP process had to viewed as a whole and any process improvements had to be viewed in terms of impact to all people working the process. The members of the team were to gather information from and report back to their constituencies, both corporately and functionally.

In addition to the AFSC team, industry put together a team at the request of General Meyer. The team is under the umbrella of the Council of Defense and Space Industry Associations (CODSIA). Mr Sam Croucher, RFP CPT Chairperson, and Mr Frank Bane, RFP CPT Industry Chairperson, have pointed out,

> Since the early CPT meetings, industry's involvement has steadily increased to the point where today the industry team plays an integral role in all CPT activities. In fact, the high level of mutual trust, shared sense of purpose, and overall teamwork which have grown out of the CPT's joint industry and government activities is considered one of the team's highlights and also one of the main reasons the CPT's efforts to improve the RFP will meet with success. (3)

## METHODOLOGY AND TRAINING

The training received was from the Cumberland Group, Inc. The ideas that they teach in their approach are very similar to other mainstream approaches to TQM. The initial training received was a week long combined team development, and initial work on the project.

Most of the techniques that are used by the Cumberland Group are not new. Among the techniques are Brainstorming, Nominal Group Techniques, and Pareto Diagrams. Many of these techniques are taught in college courses in communication, psychology, social psychology, and traditional logic. What is important here is that these techniques are reemphasized and brought back into focus.

One of the most important accomplishments of this initial session was to development of the team charter. The charter reads as follows:

> Improve the quality of our RFPs and establish a framework for all of us within AFSC to continuously improve our RFP documents and their preparation process. This framework should be capable of promptly adapting to changes in law and policy. In all cases, the RFP must be capable of:
>
> - Leading to the satisfaction of our user's needs,
> - Leading to accurate assessment of the offeror's capability to successfully deliver the required product,
> - Providing a foundation for the business relationship between parties, and
> - Insuring the offeror's ample opportunity to employ the best business and technical approaches.

## ACTION PLAN EXECUTION

Cumberland provided an approach (4) that consists of six steps:

- Plan
- Define Process
- Involve Customers/Suppliers
- Check Status of Process
- Analyze Process
- Implement Improvements

The final step, Implement Improvements, consists of a continuous cycle of Plan-Do-Check-Act.

The team tried to faithfully follow this sequential approach. The greatest difficulty for many members of the team was to fight back the disease of immediacy. At the present time the team has reached the sixth step of the process.

### Plan

After initial team development and training the team created an action plan to be accomplished over the next six month period. The team has operated most effectively when it has worked to the action plan and met with its greatest difficulty when straying from the plan. Tasks were developed, target dates selected, and responsibilities were assigned to team members. With minor revisions the team has adhered to the original schedule.

## Define Process

The first step in the review was to define the process as it exists today. The RFP process is quite large. The team established two boundaries for the process. To the left we considered the RFP process beginning at requirement identification. To the right we considered the RFP process as ending at proposal receipt.

Each team member brought a copy of their process to the initial meeting. On a huge piece of butcher paper we laid out the generic process. There was great disagreement about what events occurred, when they occurred, and terminology. By the third iteration we had a chart that we could all agree was representative of a generic process, although it was recognized that no product division accomplished the process in that manner. A copy of the chart has been reproduced to give an indication of the complexity of the process at an overview level. The RFP process consists of many subprocesses, which may only be represented by one or two blocks on this chart.

The creation of the chart was very important. Looking at the process in this manner provided some interesting insights. For example, there is no block on the chart for team formation and scheduling, the RFP process is accomplished on an ad hoc basis. Another example is that the headquarters review of the RFP is generally occurring at about the time that the offerors are submitting their proposals.

## Involve Customers and Suppliers

Getting the customer and suppliers involved in the review required a large cultural change and role reversal. The traditional view of the customer/supplier relationship has been that the Air Force is the customer and the contractors are the suppliers. It has been very difficult for the Air Force members of the team to think as suppliers, but even more difficult for both the Air Force and contractor members of the team to think of the contractors as customers.

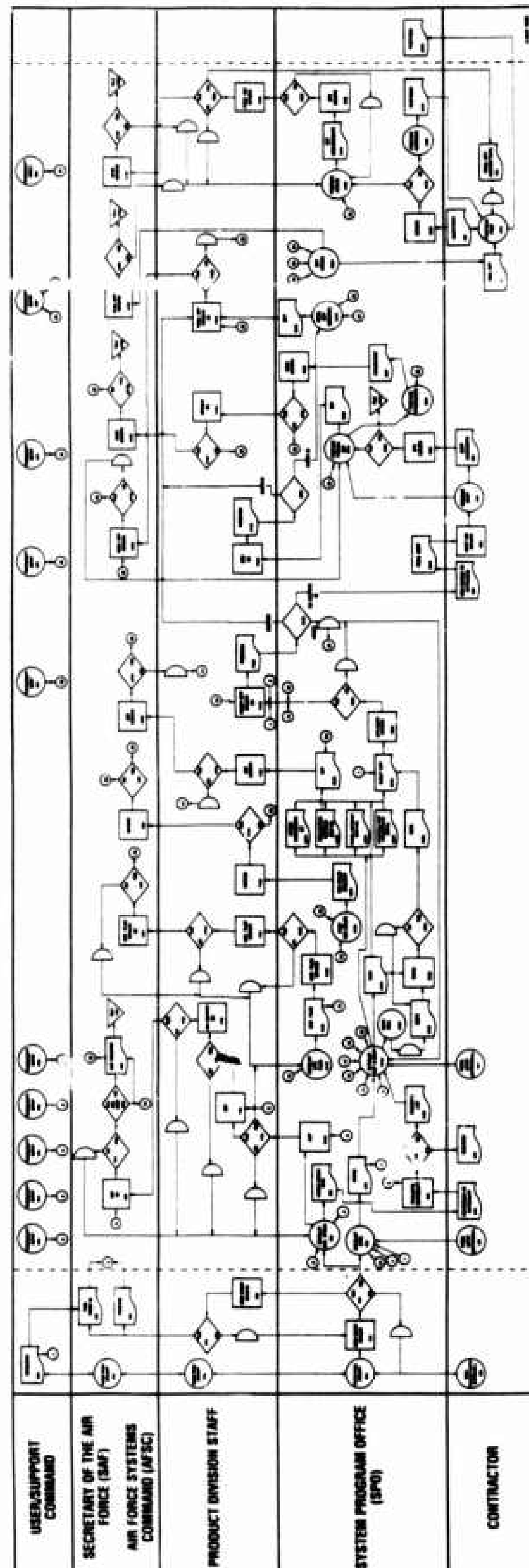
From initial inputs we developed a list of problems with RFPs and the process. After review and comment we had a list of 115 items wrong and one thing right. Among the 115 "pains" with RFPs and the process were:

- No ombudsman to mediate contractor RFP concerns.
- Too much detailed cost data in proposals.
- Specifications are too detailed and constraining.
- RFP preparation not scheduled or tracked.
- Too many CDRLs.
- Different functional agendas (i.e. "rice bowls").
- RFP format not standardized.
- Size and complexity not matched to dollar value.
- Staff/Line roles and responsibilities confused.
- "Nobody reads the whole thing."

## Check Status of the Process

Checking the status of the process involves establishing goals and measurements for both effectiveness of the product and efficiency of the process. The Boeing Aerospace Company states,

> Identify on the process flow diagram the places where measurements are being taken today.




Air Force Systems Command
Generic Request For Proposal (RFP) Process

> Measurement within a process ordinarily occurs at supplier/customer boundaries or between two process implementors. Control measurements often include completion, timeliness and accuracy. (5)

The problem with an intellectual product such as the RFP is that quality is very difficult to determine, the measures are to a large degree subjective. The quality of RFPs has usually been "measured" by the number of comments received on the review of the RFP or the number of changes required by a "Murder Board". The CODSIA group was particularly helpful here. They provided us with the results of a survey on what industry needed to be able to provide a good proposal. This was used to baseline what industry considered to be a good RFP.

Measuring the efficiency of the process is also very difficult. The only measure today is time. The data available in the Procurement Management Systems (PMS) is probably not sufficiently detailed and reliable. The starting point is not clearly defined and only a few RFP milestones are mandatory.

The team recognizes that problems with measurement will be difficult to overcome. Adding measurements may burden the system and the measurement itself may drive the results.

Analyze Process

The process was analyzed using the 115 "pains". The pains were grouped on the basis of commonality and was validated by plotting each of the 115 "pains" on the process chart to determine what groupings occurred naturally. The grouping identified fourteen targets of opportunity (TOOs):

- -Authority, Team Formation, and Scheduling
- -Acquisition Document Review and Approval
- -Concurrency
- -Communications with Offerors
- -Acquisition Strategy Development
- -Tailoring and Data and Data Call
- -Cost Data Level (WBS)
- -Congruency and Format of RFP
- -Formal and Practical Training
- -Cost or Pricing Data Certification
- -Contract Clauses
- -Changing Product Requirements
- -Policy Changes and Their Implementation
- -Legislative Initiatives

Implement Improvements

The team has reached this stage. From the TOOs we identified initial actions for initial implementation, those that have high payoff potential, but require some additional study, and those that require the establishment of longer term teams for either corrective action or review of a critical subprocess.

The AFSC Commander has written letters (6) to his product division commanders and the CEOs concerning implementation of recommendations that the process owners have accepted from the CPT. Among the initial actions were:

- -Establishing an Ombudsman
- -Launching a "Road Show" to Inform the Field
- -Emphasizing Early RFP Team Development
- -Selecting Upcoming Acquisitions for Test Cases

Among areas identified as having significant potential for improvement were the WBS level required for cost or pricing data and the development of CDRLs.

In addition, the Commander stated,

> The focus of this entire improvement project rests on industry-government team-building. Our goal is positive not adversarial business relationships. In the early stages of acquisition strategy planning we must communicate openly and effectively, and carry that teamwork through the RFP process and into the ensuing program. As a sign of my commitment, I have reemphasized policies such as our preference for cost reimbursement type contracts for full scale development and requiring certified cost or pricing data only when adequate price competition does not exist. (6)

SUMMARY

All of those who have reviewed the results of to date have considered it a success. The mapping of the generic RFP process, alone, would have made the team a success, because it will be a great educational tool. But there are many more recommendations that the team will be able to make in the months to come. General Randolph clearly demonstrated his understanding of the cultural change necessary to implement TQM when he was briefed by the team on "preliminary" results of the process review after seven months. General Randolph indicated that he expected the team to stay together for at least two more years while we continually improved the process.

The success has been a result of the commitment of team members, the process owners, and management. The AFSC Commander has shown his commitment to Total Quality Management through support of the joint AFSC and industry team. The product division commanders have shown their support for the Critical Process Team by making the team members participation their number one priority. The industry members of the team have received the same support. Together we will all be able to use Total Quality Management to continually improve the Request for Proposal process.

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DSP COOPERATIVE COST EFFECTIVENESS INITIATIVE (DSP CCEI): A "MODEL PROGRAM" APPLICATION OF THE TQM PHILOSOPHY

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Redondo Beach, CA 90278

ABSTRACT

This paper describes a "model" cost and productivity savings initiative which extensively employed the principles of total quality management, including the concepts of could cost, acquisition streamlining, and value engineering.

1. THE INITIATIVE

The Defense Support Program Cooperative Cost Effectiveness Initiative (DSP CCEI) Charter states the following:

> The DSP Cooperative Cost Effectiveness Initiative, a voluntary, cooperative effort of TRW S&D Sector, the AFSD/CND (DSP SPO), and the AFPRO TRW, will examine DSP production contracts, Block 18 primary and Block 14 secondary, to determine where prudent management decisions could result in decreased cost to the government.

The DSP CCEI is a component of a cost control initiative between TRW Space & Defense (S&D) Sector and AFPRO TRW and a follow-on extension of the Intensified Commitment to Overhead Management (ICOM) initiative performed by TRW S&D Sector from 1985 to 1987 (see Appendix I for the agreement).

TRW S&D Sector and AFPRO TRW began the DSP CCEI with the agreement to develop and apply cost and productivity savings methodology focusing on a single program but having broader application. The methodology of DSP CCEI was developed with consideration given to potential exportation to other DOD programs.

The principles of Total Quality Management (TQM) were applied to the initiative. Figure 1 gives the conceptual framework to TQM. Extensive use was made of employee involvement and continuous process improvement. For purposes of the initiative, "quality" was defined as the ability of TRW to satisfy end-user customer needs and expectations now and in the future at an acceptable level of economic affordability. A fundamental premise adopted by the


Figure 1. Total quality management conceptual framework

initiative is that while cost and productivity savings will result from the implementation of the recommendations of this initiative, the quality of the DSP satellite will also be enhanced through continuous process improvement.

The DSP CCEI has been transitioned into the DSP Total Quality Management Initiative (DSP TQMI), which has been extended to employ on an on-going basis total employee involvement and to focus on continual improvement of all critical processes on the DSP program.

2. METHODOLOGY

Total employee involvement was the essential component of this voluntary, cooperative effort. The activity was directed toward the common goal of determining where prudent management decisions could result in decreased cost to the government. Everyone supporting the initiative was, and continues to be, involved in continuous process activities directed toward improving performance at every level on the DSP.

The organization of the DSP CCEI effort is shown in Figure 2. The Management Council established overall policy and direction for the initiative. The Coordinating Council facilitated accomplishment of ongoing efforts as directed by the Management Council. Ten joint task forces, each under the leadership of a senior TRW manager, performed specific cost-effectiveness investigations and assessments (Figure 3). Action teams performed specific cost-effectiveness investigations and assessments (Figures 4 through 6).

The process linking the organizational entities is shown in Figure 7.

The DSP CCEI began on 23 June 1988 with the signing of the agreement by E. D. Dunford, executive vice president and general manager, TRW S&D Sector. Immediate implementation actions for time-sensitive cost and productivity savings began as soon as they were identified and agreed to. Further final implementation recommendations will occur at the end of the initiative on 31 December 1989, or earlier, as they are identified and agreed to.

- **Management Council**

| | | |
|---|---|---|
| TRW | D.C. Stager | J.C. Howe |
| AFSD/CND (DSP SPO) | Col. W.J. Craft | Capt. F. W. Kenniasty |
| AFPRO TRW | Col. C.F. Stewart, Jr. | Capt. C.E. Marshall |

- **Coordinating Council**

| | |
|---|---|
| TRW | J.C. Howe |
| AFSD/CND (DSP SPO) | Capt. F.W. Kenniasty |
| AFPRO TRW | Capt. C. E. Marshall |

- **Joint Task Forces**
- **Action Teams**
  - TRW
  - AFSD/CND (DSP SPO)
  - AFPRO TRW

Figure 2. Organization of effort

DSP Data Management, Configuration Management, and Software Assurance (*Leader:* F.G. Holmes)

DSP Reliability and System Safety (*Leader:* R.N. Miller)

DSP Specifications, Standards and Related Documents (*Leader:* A.M. Terry)

Contractual and Legal Mechanisms to Effect Cost Savings on DSP (*Leader:* K.Z. Herr)

DSP Project Management Tools and Systems (*Leader:* R.A. Newcome)

DSP Quality Assurance (*Leader:* A.J. Hutton)

TRW as Total DSP Systems Integrator (*Leader:* B.S. Vogt)

DSP Requirements (*Leader:* A.M. Terry)

DSP Electronic Transfer of Data (*Leader:* R.L. Davis)

DSP Manpower Management (*Leader:* J.A. Gliksman)

Figure 3. Joint task forces

- Review suitability of specifications, standards, and related documents *
- Assess organizational effectiveness *
- Determine potential cost reductions in Assembly and Test Operation (ATO) *
- Explore cost reduction improvements in Systems Effectiveness *
- Explore cost reduction improvements in Manufacturing *
- Determine potential cost reductions in Launch Operations *
- Review suitability of program management tools and systems *
- Assess potential for subcontracting simulator spares *

Employee Participation

Figure 4. Identified areas of potential interest—TRW action team

- Review suitability of specifications, standards, and related documents *
- Assess organizational effectiveness *
- Review suitability of program management tools and systems *
- Determine potential cost reductions in Launch Operations *
- Assess potential for AFPRO negotiation of change proposals, deviations, and waivers *
- Investigate potential for electronic transfer of data *
- Investigate satellite/sensor integration *
- Assess contractual matters and relationships *

Employee Participation

Figure 5. Identified areas of potential interest—AFSD/CND (DSP SPO) action team

- Review suitability of specifications, standards, and related documents *
- Assess organizational effectiveness *
- Explore cost-reducing improvements in Quality Assurance *
- Explore cost-reducing improvements in Manufacturing *
- Review suitability of program management tools and systems *
- Assess potential for AFPRO negotiation of change proposals, deviations and waivers *
- Assess MRB process *
- Investigate potential for electronic transfer of data *
- Explore potential for reducing DSP manpower *

Employee Participation

Figure 6. Identified areas of potential interest—AFPRO TRW action team

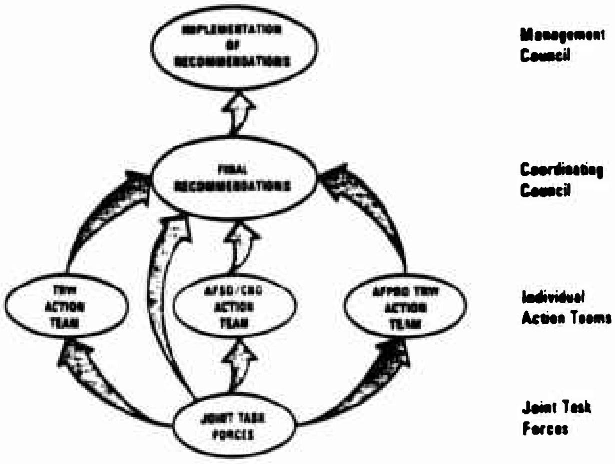


Figure 7. The process

| | Bogey* |
|---|---|
| • Review suitability of specifications, standards, and related documents | \$1M |
| • Assess organizational effectiveness | \$4M |
| • Determine potential cost reductions in Assembly and Test Operation (ATO) | \$15M |
| • Explore cost reduction improvements in Systems Effectiveness | \$2M |
| • Explore cost reduction improvements in Manufacturing | \$1M |
| • Determine potential cost reductions in Launch Operations | \$1M |
| • Review suitability of program management tools and systems | \$1M |
| Total goal | \$25M |

*Block 18 only through 31 December 1989

DSP cost reduction goal: \$25M

Figure 8. TRW management: Cost reduction bogeys for identified areas of potential interest

Specific cost reduction bogeys were established for TRW action teams (Figure 8). Section 3 presents the results obtained against these bogeys. The setting of "realistic" bogeys was an important task affecting the Initiative's outcome. The bogeys were established by the Program Manager after examining the existing contract budgets and the proposed scope of work effort in each area. Early attempts to have performers establish their own bogeys were not successful. In the future, means must be found to establish an approach whereby action teams can set their own bogeys.

In developing the DSP CCEI, we considered the DOD quality and cost effectiveness initiative drivers as delineated in Figure 9. Considerable attention was given to applying the acquisition techniques of could cost, acquisition streamlining, and value engineering, wherever appropriate. A should cost was performed on DSP Block 18 before DSP CCEI began. Figure 10 summarizes each of these acquisition techniques.

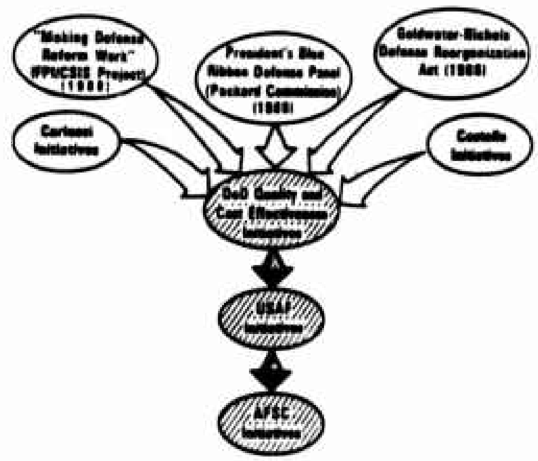


Figure 9. Drivers for the Initiative

**Could Cost**

- Aimed at reduction of program cost by focusing on the integration of the acquisition process, elimination of nonvalue added work by the contractor, and improvement of overall contractor performance
- Could cost means *cooperative effort*, i.e., Government and contractors working together to give the best quality product, on schedule at the lowest possible cost

**Acquisition Streamlining**

- Actions resulting in more productive use of resources to develop, produce, and deploy quality defense programs
- Only cost-effective requirements should be included, at the most appropriate time, in program solicitations and contracts
- Government should *specify performance requirements*, and contractor should *decide how to perform* against them

**Value Engineering**

- Seeks to identify and reduce nonessential procurement and program costs
- Seeks to achieve essential functions at the lowest life cycle cost
- The Value Engineering Change Proposal (VECP) is the principal mechanism for implementing cost reductions

**Should Cost**

- Seeks to minimize the ill effects of cost-based pricing with its tacit acceptance of will cost as a standard
- The Should Cost concept holds that the objective of cost analysis and contract pricing is to price on the basis of what it should cost the offeror to produce, assuming reasonable economy and efficiency of operation

Figure 10. Could cost, acquisition streamlining, value engineering, and should cost

The most fundamental premise of DSP CCEI was "Everything should be questioned!" Figure 11 outlines the comprehensive areas of contract structure examined during the initiative which resulted in the cost and productivity savings recommendations reported in Section 3.

All specifications, standards, related documents (e.g., CDRLs, DIDs), or contract provisions were open to challenge, except those required by law; and all top-level policies (e.g., AFSD Commander's Policies, TRW Core Manual System) were reviewed for potential cost-effective streamlining.

- **Review suitability of requirements**
- **Review suitability of statements of work (SOWs)**
- **Review suitability of standards, specifications, and related documents**
- **Review suitability of contract data requirements lists (CDRLs)**
- **Review suitability of contract terms and conditions**
- **Determine potential for increased competition**

**Employee Participation**

Figure 11. Identified areas of potential interest–contract structure

The overall goal of the DSP CCEI was to continuously improve quality, improve productivity (effectiveness and efficiency), reduce manpower, shorten schedules, and thereby reduce cost of the DSP to the government. Consideration of the dynamic interaction of program risk elements of technical performance, schedule, and cost was essential in developing the cost and productivity savings recommendations of the initiative. Since contractor TQM efforts are being assessed through the AFSC Contractor Performance Assessment Reporting System (CPARS), full attention was given to all of the elements of program balance (Figure 12).

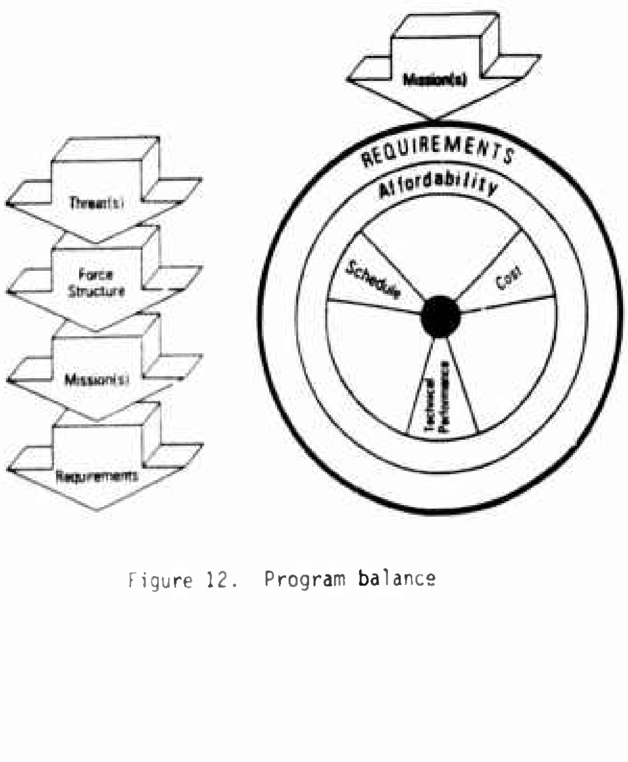


Figure 12. Program balance

## 3. RESULTS

The joint task forces and action teams identified at least 213 potential cost saving ideas. The ideas were developed into 57 final cost and productivity savings recommendations. Appendix II contains an example of a detailed development of one of the 57 final recommendations.

The cost savings under this initiative take two forms – cost reductions and cost avoidances. Cost reductions are further categorized as Type 1 and Type 2. A Type 1 cost reduction is defined as a cost saving leading to a budget reduction and a decreased cost to the contract, while a Type 2 cost reduction is a future cost saving leading to a reduction in anticipated budget. In the second instance, the government has known requirements which need to be contractually implemented but due to the Type 2 cost reduction may no longer need full implementation. A cost avoidance is a cost saving for work that may take more funds than TRW has budgeted due to unforeseen circumstances.

Another category of savings was developed under this initiative – productivity savings. Productivity savings are time savings resulting from doing work more effectively and efficiently. In general, productivity savings are not concentrated enough, in one organization, or of great enough magnitude, to allow a reduction in personnel which would lead to a cost reduction.

Table 1 summarizes cost and productivity savings recommendations by functional area. These areas closely parallel the joint task force and action team efforts which resulted in the recommendations. Sixty-six percent of the savings were developed in the assembly and test area. This was expected since DSP Satellites 14 through 18 are currently in the assembly and test phase. Both TRW and the government used their extensive, recent experience in assembly and test to develop these cost savings recommendations.

The joint task forces and action teams also identified many potential cost and productivity savings ideas which might be implemented on future contracts. These ideas were not fully developed as a part of this initiative because immediate savings could not be realized on the existing contracts. These ideas will be revisited when the next block of DSP satellites is ready to be contracted.

Table 2 summarizes cost and productivity savings recommendations by concurrence category. There are three categories – fully concurred, generally concurred, and nonconcurred. When a recommendation is fully concurred, it is agreed to by all parties and is ready for implementation. Actual implementation is subject to contractual authorization by the contracting officer after negotiations. Generally concurred recommendations require additional development and/or coordination. Nonconcurred means one or more of the three organizations did not agree on a recommendation. The recommendations reported in this category are still being developed and coordinated to provide for their justification as viable, fully concurred recommendations.

Forty-six of the 57 final recommendations are fully concurred. The forty-six recommendations contribute approximately 50 percent of the total cost and productivity savings. Approximately $15M of

Table 1. DSP CCEI Summary of Recommended Savings

| Functional Area | Cost Savings ($1000) | | | Productivity Savings ($1000) | | Total Savings ($1000) |
|---|---|---|---|---|---|---|
| | Cost Reduction Type I | Cost Reduction Type II | Cost Avoidance | Dollarized Time Savings | Implementation Cost | |
| Systems Engineering | 1729 | 326 | 0 | 0 | 0 | 2055 |
| Systems Effectiveness | 1643 | 0 | 230 | 0 | 0 | 1873 |
| Program Management | 859 | 424 | 0 | 5789 | 951 | 6121 |
| Manufacturing | 0 | 0 | 0 | 0 | 0 | 0 |
| Organizational Effectiveness | 0 | 405 | 0 | 0 | 0 | 405 |
| Orbital Operations | 2803 | 1503 | 0 | 0 | 0 | 4306 |
| Assembly & Test | 19072 | 2978 | 7089 | 0 | 0 | 29139 |
| Totals | 26106 | 5636 | 7319 | 5789 | <951> | 43899 |
| Less Duplication* | <350> | | | | | <350> |
| Net Total | 25756 | 5636 | 7319 | 4838 | | 43549 |

*Note: Duplication refers to the fact that some of the recommended changes overlap. If two changes that overlap are implemented, then full cost savings on both will not be attained.

Table 2. DSP CCEI Summary of Recommended Savings

| Functional Area | Cost Savings ($1000) | | | Productivity Savings ($1000) | | Total Savings ($1000) |
|---|---|---|---|---|---|---|
| | Cost Reduction Type I | Cost Reduction Type II | Cost Avoidance | Dollarized Time Savings | Implementation Cost | |
| Fully Concurred | 13285 | 2081 | 2553 | 4969 | 951 | 21937 |
| Generally Concurred | 1190 | 663 | 4766 | 820 | 0 | 7439 |
| Nonconcurred | 11631 | 2892 | 0 | 0 | 0 | 14523 |
| Totals | 26106 | 5636 | 7319 | 5789 | <951> | 43899 |
| Less Duplication* | <350> | | | | | <350> |
| Net Total | 25756 | 5636 | 7319 | 4838 | | 43549 |

*Note: Duplication refers to the fact that some of the recommended changes overlap. If two changes that overlap are implemented, then full cost savings on both will not be attained.

recommendations are still in the nonconcurred category which contains three recommendations. One of these recommendations, deletion of thermal vacuum testing, has an estimated savings of $13M, which is 30 percent of the total savings recommended under the initiative. Efforts continue to gain full concurrence on this recommendation.

In summary, cost and productivity savings recommendations in excess of $43M were proposed by the joint efforts of TRW, AFSD/CND (DSP SPO), and AFPRO TRW. Of these, $22M have been recommended for implementation, and work is continuing on an additional $21M in the generally concurred and nonconcurred categories.

May 26, 1988

## COOPERATIVE COST EFFECTIVENESS INITIATIVE

### PURPOSE

It is in the best interests of the Government and TRW Space & Defense Sector that TRW's operations and AFPRO's Government oversight activities be conducted in a cost effective manner. This mutual interest is exemplified by this document which formalizes an executive-level commitment by both TRW and the Air Force Plant Representative Office (AFPRO) to establish and pursue certain long-range objectives for cost control. This document is not contractually, nor in any other way, binding and does not limit the rights of either party in any contractual or administrative proceeding.

### OBJECTIVES

The objectives of this Program are to:

- Promote cooperation between TRW and the AFPRO through the establishment of a long-range cost reduction goal

- Assist in identifying and implementing management actions at TRW to promote efficient operations and reduce cost

- Aid in eliminating inefficient, redundant operations or uneconomical government requirements that adversely impact contract costs, and

- Enhance the use of the business, technical and financial expertise of TRW and the AFPRO through increased joint focus on major cost effectiveness initiatives.

### PROCEDURE

The TRW S&D General Manager and the Air Force Plant Representative jointly will establish and chair a Cost Effectiveness Executive Committee for the purpose of furthering their mutual objective to control cost. The Executive Committee will consist of senior level executives from both TRW and the AFPRO and will provide the oversight and direction for the implementation of selected major cost effectiveness initiatives. The Executive Committee will review cost effectiveness initiatives proposed by TRW and AFPRO representatives to be included in the Program and can recommend other areas of potential cost savings for preliminary study and possible inclusion in this Program. A lead manager will be designated by the Committee for a preliminary study area and for each specific cost effectiveness initiative which the Committee has decided will be an element of the Program. The lead manager will be responsible for the presentation to the Committee of findings and recommendations regarding an area identified for study as to the possible formulation of a cost effectiveness initiative. For an initiative included in this Program, the lead manager will be responsible for providing the Committee with a description of the initiative and related implementation plan, an analysis of net cost savings to be obtained and the method by which these savings can be validated. In addition, the lead manager periodically will advise the Committee on the implementation progress of the initiative and the status of the validation of cost savings and will prepare a final report when implementation has been substantially complete or at the termination of this Program if implementation actions will be continuing beyond the end-date of the Program.

PROGRAM GOAL

A dollar goal of savings in TRW Space & Defense costs from initiatives to be carried out under this Program will be established by September 30, 1988. This goal will represent current-year savings to be realized from cost effectiveness initiatives implemented, totally or partially, during the period of this Program.

TERMS

This document is effective upon signature of the Parties and continues until December 31, 1989. It may be modified by mutual consent or canceled by either Party if it is determined that its purpose is not being efficiently achieved.

For the Air Force Plant Representative Office

Charles P. Stewart Jr.

CHARLES P. STEWART, JR.
Colonel, USAF
Air Force Plant Representative

Date: June 16, 1988

For TRW

E. D. Dunford

E. D. DUNFORD
Executive Vice President and General Manager, TRW Space & Defense Sector

Date: 6-23-88

APPENDIX II. DETAILED DEVELOPMENT OF A FINAL RECOMMENDATION (Typical)

DSP CCEI FINAL COST SAVINGS RECOMMENDATION A08

SUMMARY OF RECOMMENDATION RECOMMENDATION NO. ______

RECOMMENDATION TITLE Review top specifications and convert to broad mission requirements.

RECOMMENDATION

Review system Spec (DSP 80-01), System Segment Spec (SY1-78) and the Prime Item Spec (SY1-79) and convert to broad mission requirements.

EXISTING SITUATION

Many unneeded specification requirements have accreted over the years, resulting in a verification program which contains many unnecessary items flowed down from the parent specification, as well as numerous items not stemming directly from the satellite level requirements. This results in a test program which is significantly more expensive than necessary.

RECOMMENDED CHANGE

It is recommended that the system specification, DSP 80-01, be rewritten in a performance requirement format, eliminating numerous detail design requirements in the current version. This would lead to a requirements flowdown and similar rewrite of the segment and satellite specifications, SY1-78 and SY1-79, together with their corresponding verification matrices and plans.

CHANGE IMPACT ASSESSMENT

| Cost Avoidance | Cost Reduction | Schedule Impact | Technical Risk Exposure | | | Implementation | | |
|---|---|---|---|---|---|---|---|---|
| | $701K | | | | | | | |
| Productivity Savings | | Program Days Saved ____ | Low | Moderate | High | Easy | Moderate | Hard |
| [ ] Yes | [ ] No | Crew Days Saved ____ | [X] | [ ] | [ ] | [ ] | [X] | [ ] |

Page 1 of 5

CONSENSUS STATEMENT OF JOINT TASK FORCE — RECOMMENDATION NO A08

| ORGANIZATION \ POSITION & RATIONALE | CONCUR | DO NOT CONCUR | NOT APPLIC-ABLE | |
|---|---|---|---|---|
| TRW | X | | | Rewrite the System, Segment and Satellite specifications to stress performance rather than design requirements. This will eliminate many unneeded requirements and might also bring to light neglected system requirements which should receive more attention. Also rewrite corresponding verification plans, test plans and procedures to reflect the new style specifications. The resulting test program would contain fewer but more incisive tests. Since the A&T schedule is a major cost driver, the potential for significant saving is there. |
| AFSD/CND (DSP SPO) (INCLUDING AEROSPACE CORP.) | X | | | Concur with Step 1 of Recommendation to proceed with Feasibility Study. |
| AFPRO TRW | | | X | |

PAGE 2 OF 5

DETAILED ANALYSIS OF RECOMMENDED CHANGE — RECOMMENDATION NO. A08

The current system spec if rewritten could result in significant opportunity for a major cost reduction for DSP. This reduction could be realized if we consider rewriting DSP 00-01, the system spec, in a performance requirement format, eliminating the numerous detail design requirements in the current version. This would logically lead to a requirement flowdown and similar rewrite of the segment and satellite specs, SY1-78 and 79. The rewrites would eliminate many unneeded requirements which have accreted over the years, and might also bring to light neglected system requirement which should receive more attention.

The cost reduction potential in this process arises from the observation that the satellite test program follows from the spec content, and has also accreted numerous items not stemming directly from satellite level requirements. It has historically been very difficult to eliminate tests, particularly when their original purpose has been forgotten.

It appears likely that if a new verification plan were developed from the new style specifications, the resulting test program would contain fewer but more incisive tests. Since the A&T schedule is a major cost driver, the potential for significant saving is there.

The counterbalancing cost risk is that implementing changes to the test program may be expensive, and is likely to run into general opposition to radical change. Therefore it is proposed that the initial step be a detailed study of the costs, benefits, and risks of the above program revisions, as detailed in step 1 of the attachment.

COST SAVINGS ANALYSIS — RECOMMENDATION NO. A08

[illegible]

- COST REDUCTION [X]
- COST AVOIDANCE [ ]
- PRODUCTIVITY SAVINGS [ ]

IMPLEMENTATION COSTS:

| TASK | [illegible] |
|---|---|
| | |
| TOTAL IMPLEMENTATION = | 0.0 |

COST AVOIDANCE: [illegible]

| [illegible] | DAYS | [illegible] | TOTAL |
|---|---|---|---|
| 16 | 0 | 90.3 | 0.0 |
| 17 | 0 | 43.1 | 0.0 |
| 18 | 0 | 27.3 | 0.0 |
| 19 | 0 | 94.7 | 0.0 |
| 20 | 0 | 47.0 | 0.0 |
| 21 | 0 | [illegible] | 0.0 |
| 22 | 0 | [illegible] | 0.0 |
| TOTAL AVOIDANCE = | | | 0 |

NET COST AVOIDANCE = 0.0

IMPLEMENTATION COSTS:

| TASK | [illegible] |
|---|---|
| FEASIBILITY STUDY | 60.0 |
| SPECIFICATION REWRITE | 120.0 |
| MODIFY VERIFICATION PLANS | 120.0 |
| MODIFY TEST PLANS | 60.0 |
| MODIFY TEST PROCEDURES AND SOFTWARE | [illegible] |
| TOTAL IMPLEMENTATION = | [illegible] |

COST REDUCTION: [illegible] 22 , 4 DAYS PER [illegible] *

| [illegible] | DAYS | [illegible] | TOTAL |
|---|---|---|---|
| 16 | 0 | 90.3 | 0.0 |
| 17 | 0 | 43.1 | 0.0 |
| 18 | 4 | 27.3 | [illegible] |
| 19 | 4 | 94.7 | [illegible] |
| 20 | 4 | 47.0 | [illegible] |
| 21 | 4 | [illegible] | 114.4 |
| 22 | 4 | [illegible] | [illegible] |
| TOTAL REDUCTION = | | | [illegible] |

NET COST REDUCTION = 701.2

NET COST AVOIDANCE = 0.0
NET COST REDUCTION = 701.2

NET COST SAVINGS = 701.2

* [illegible]



RECOMMENDED CHANGE IN CONTRACTUAL LANGUAGE — RECOMMENDATION NO. A08

| EXISTING TEXT | REVISED TEXT |
|---|---|
| DSP 80-01 System Spec | Rewrite DSP 80-01 |
| SY1-78 System Segment Spec | Rewrite SY1-78 |
| SY1-79 Prime Item Spec | Rewrite SY1-79 |
| | These changes will be specified as a result of the feasability study (Step 1). |

# SDIO TQM IMPLEMENTATION

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## ABSTRACT

The Strategic Defense Initiative Organization (SDIO) faces monumental management and technological challenges unmatched by any program in history. SDIO must integrate the most advanced technologies into a militarily effective and affordable ballistic missile defense system. Achievement of this task requires the utmost in management innovation and initiative, particularly since most SDI tasks are executed by "agents."

SDIO has chosen Total Quality Management (TQM) as one of the cornerstones of its approach to meeting the challenges associated with a leading edge technology program that relies on a complex structure of organizations and interfaces to accomplish its mission. SDIO TQM implementation is targeted at both the internal organization and the external executing agents, who report to their respective Service or Agency responsible for managing SDI technology projects and element programs. To effectively develop and implement a TQM strategy, SDIO must be able to harmonize its TQM goals with the independently developed TQM goals of the executing agent organizations so that an optimized, "best-for-the-government," set of mutual goals are established.

The objective of the SDIO TQM strategy is to create an environment among all of the participants, government and contractors alike, in which there is full convergence of goals and a unified approach to the design and development of the Strategic Defense System (SDS). The SDIO TQM strategy will be supported by analytical research and economic analysis to develop innovative incentives and measures for TQM goal achievement.


## INTRODUCTION

The SDIO was chartered in 1984 as a result of President Reagan's 1983 speech establishing ballistic missile defense as a national goal. The resulting joint service organization reports directly to the Secretary of Defense (SECDEF), and operates simultaneously as a headquarters, a program office, a laboratory, and a test facility. It manages both system development programs and technology projects.

The majority of the system development and technology contracts are executed by the Services and other DoD Agencies. SDIO is responsible for directing the technological and programmatic actions and for accomplishing the system integration of the SDS, whereas the executing agents are responsible for the detailed design and execution of the elements that, when integrated, make up the SDS. The executing agents, therefore, directly manage the vast majority of contractor activities. This arrangement is depicted in Figure 1.

SDIO provides guidance to the Army and Air Force, which are responsible for executing the element programs development and procurement. SDIO also coordinates with the element program offices through the System Element Managers within SDIO and the Systems Engineering (SE) contractor who is responsible for integrating the overall interfaces and requirements.

This complex management environment offers SDIO unlimited opportunities for the implementation of TQM for both management and technological processes. SDIO recognizes that TQM has yielded significant benefits when applied in the commercial sector. At the same time it is realized that implementation of TQM in a government setting, where there is no unifying motive of profit and market competition, will place unique demands on implementation of TQM. For this reason, TQM implementation in the SDI program must be tailored to meet the needs of all program participants, both internal and external.

## IMPLEMENTATION

To achieve the TQM objective, SDIO has initiated an organization-wide implementation that begins with the commitment and full support of the Director, SDIO, Lt. Gen. George Monahan. He has approved a series of initial steps including an orientation workshop, a professionally facilitated TQM off-site, and a series of pilot implementation actions to gain experience in support of implementing TQM across the SDI program.

Recently, Lt. Gen. Monahan hosted an SDIO TQM Orientation Workshop to provide key members of the SDIO Team with an up-to-date view of TQM in both government operations and industry.. Individuals with specific TQM experience presented their successes and lessons learned to acquaint SDIO personnel with the potential benefits that can be achieved through application of this management concept. The Orientation Workshop will be followed by a professionally facilitated, full day off-site in mid-September, at which time the TQM goals and objectives for the SDI program will be clearly es-

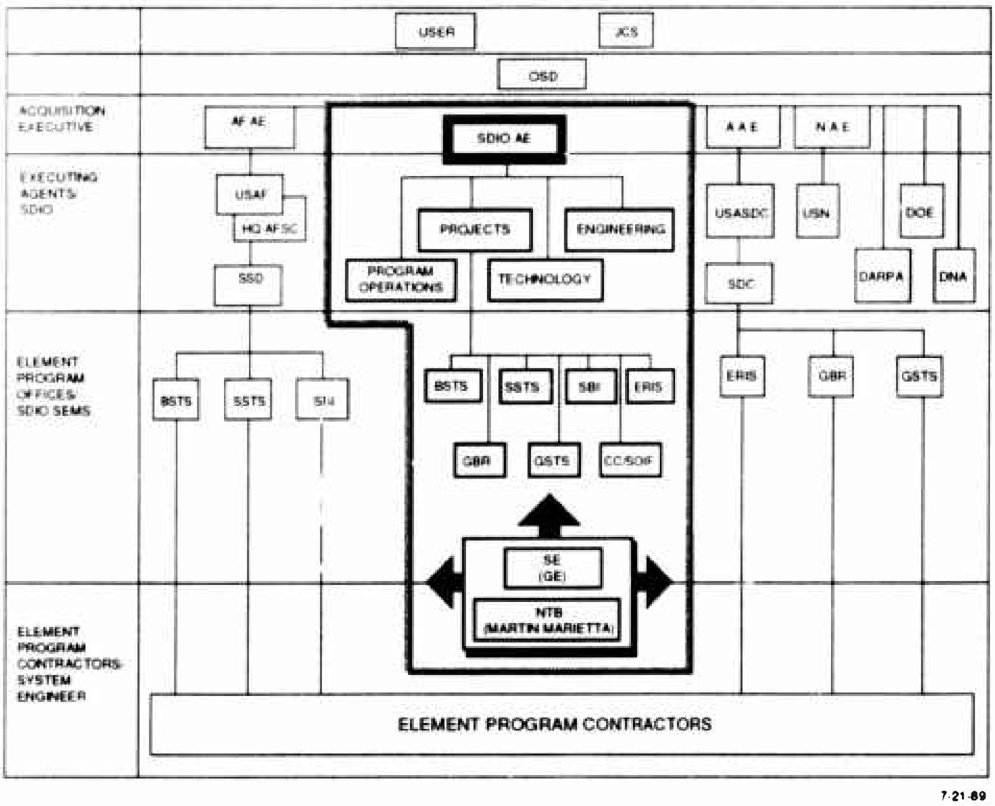


Figure 1 SDIO Acquisition Environment

tablished. This will lead to a well formulated TQM implementation plan and ultimately to the creation and use of process action teams to improve the processes that affect the SDI program. The strategy is to first implement TQM within the SDIO organization and then to expand to include all SDI participants, especially the executing agents.

To ensure the TQM implementation plan is truly effective and tailored to SDIO, several actions to gain experience are already underway. These include: a pilot TQM implementation involving a small sample of 12 individuals in a sub-element of the organization; a process action team to examine innovative approaches in contract management; a survey of all SDI personnel and interviews with key people; and an extensive data collection effort to develop a base of knowledge and experience on Service and system program TQM efforts. A brief description of each of these actions follows.

SDIO Pilot Program

The initial step in the pilot program was to survey and interview 12 staff members to assess the internal environment with respect to existing quality initiatives and knowledge of TQM. Five specific areas were addressed: history, climate, process, tools, and outcomes. The results demonstrate that the selected staff members have high ethical standards, take pride in their work, and accept responsibility for their successes and failures regardless of the impediments involved. They believe that management encourages them to be creative and take risks (as expected given the nature of the program), and they believe that their customers are basically satisfied with the quality, quantity, and timeliness of their services. As expected, there were various levels of understanding of TQM and skepticism about its application to SDIO. These results indicate that there is fertile ground for the implementation of TQM in SDIO and the people certainly are motivated to do their jobs as best they can.

The next steps in the pilot implementation are training and the development of a realistic, executable implementation plan. To achieve this objective, a tailored training program is being developed which will teach basic TQM techniques as well as address particular opportunities identified by the surveys and interviews. The training will enable the organization to establish formal process action teams to seek improvement in the technical and management process areas that they own. These teams will be supported with appropriate analytical and economic analysis to gain real insight into the impediments to good management and benefits that could be expected from specific actions. Initial results should be available to support the TQM off-site in September.

Process Action Team

An internal process action team has been formed to examine innovative approaches to contract management within SDIO. This was done to gain experience in process action team operation and to enhance SDIO's ability to manage its highly active contracts function. The purpose of the team is to identify impediments to good internal contract management and to evaluate ways to remove these barriers. The team is reviewing the SDIO contracting process from initiation through award. Special emphasis is being focused on source selection, the administrative process, legal reviews and funding. The chairman of the team is the Deputy Director of Contracts. This team is designed to yield a near term demonstration of TQM benefits and lessons learned which can be applied across the SDI TQM process and also be available to support the TQM off-site.

A second joint process action team will be formed to review the contracting impediments identified in a survey of SDI's users, namely, the element program contractors. The objective is to remove specific impediments in the contractor relationships that do not add value to SDI products or services. To ensure the team is representative of the SDI environment, the team will consist of members of the SDIO, Service staff, prime and subcontractors, and SETA contractors. To date, both the internal and joint teams' efforts are expected to result in increased teamwork, improved procedures, and reduced program costs.

Survey and Interviews

To support the overall implementation and specifically to provide insight for the off-site in September, a TQM survey of all SDIO personnel will be taken. This survey will help SDIO to understand the organization's knowledge of TQM, its sense of quality, and how individuals view their role in SDIO and SDI's role in DoD.

The survey being used is an existing instrument developed for DoD applications and has been used at several facilities as a self assessment tool. It is designed to identify TQM needs and advance TQM awareness among the people surveyed. Four areas are addressed in the survey: organizational climate; quality/productivity-related processes; tools; and outcomes related to mission accomplishment. The responses are consolidated to identify existing initiatives and capabilities within the organization which can be capitalized on to improve quality. The entire SDIO staff will be given the survey.

Interviews of selected individuals from various levels within SDIO will also be conducted. They will cover some of the same topics as the survey, but will allow for more in-depth investigation of specific ongoing initiatives and opportunities for quality improvement within the organization. The interview findings will be used to validate and enhance the survey results. The final report will combine this information to establish a TQM baseline for the September off-site. The results will be used to help SDIO develop TQM goals and objectives at the off-site.

Data Collection

SDIO is gathering data on the TQM implementation programs from other DoD agencies and industry. The purpose of this is two-fold; first, to gain an understanding of the full range of TQM activities from OSD to contractors. This will help SDIO to develop an appreciation for the benefits that TQM can bring. Second, lessons can be learned about impediments and innovative approaches that may be applied directly and immediately to SDIO and element programs - especially in the area of acquisition strategies. All of this information is being compiled in a data base that will be available as a resource to the process action teams.

The data collection effort is divided into three major activities: collection of TQM data from commercial industry, the Services, and SDS program elements. The industry data emphasis is on the long term lessons learned and benefits derived from well established company TQM programs. Although TQM as a unified concept is relatively new to the Services, quality improvement initiatives are not. Therefore, this data collection effort focuses primarily on identifying quality initiatives which have yielded substantial benefits in the DoD acquisition environment. Finally, data is being collected to identify current TQM efforts by SDS program elements and resulting lessons learned. A secondary purpose is to establish a basis for sharing lessons learned from industry and other Service programs.

An initial review of two of the SDI element programs, the Space Based Interceptor (SBI) and Advanced Launch System (ALS), indicates that significant TQM activity is already underway. These organizations have had some program office personnel trained in the TQM concept and implementation techniques. SBI, which was designated as the TQM pilot element program, has established a TQM working group, involving both program office and contractor personnel, which is concentrating on improving existing processes. In addition, a monthly newsletter has been initiated by SBI to report on advances that result from TQM implementation.

The ALS program office has placed special emphasis at the contractor level on the application of TQM tools and techniques to solve technical problems. As a result, all ALS contractors have active TQM programs in process. These programs have already shown significant positive results, especially in the area of design improvements. Continued emphasis on collecting this type of information will directly contribute to a successful TQM implementation for the entire SDI program and foster a sharing of good ideas and innovative actions throughout the network of SDI participants.

CONCLUSION

Lt Gen Monahan and the SDIO understand that implementation of TQM requires a commitment of time and resources without specific knowledge of the benefits to be derived. Experience has shown, however, that TQM is changing the traditional views of quality in America and can be effectively applied to the SDI program. SDIO recognizes the need to demonstrate its commitment to TQM and to provide the leadership to the SDI community to make it work for SDIO and for the nation. Gen. Monahan has set the wheels in motion so that TQM can indeed provide the means for establishing the open and innovative environment that the SDI program must have in order to produce a militarily effective and affordable Strategic Defense System.

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# THE DYNAMICS OF TOTAL QUALITY MANAGEMENT: FERTILE AREAS OF RESEARCH

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## ABSTRACT

Led by the Department of the Navy and civilian industry experience, the Secretary of Defense issued a memorandum on 30 March 1988 emphasizing the Total Quality Management (TQM) effort "as the vehicle for attaining continuous quality improvement in our operations, and as a major strategy to meet the President's productivity objectives." Attached to this memo was a DOD Posture Statement on Quality, emphasizing a cultural change to require continuous improvement; emphasizing quality and productivity improvement; changing the concept of quality from inspection to designing and building quality into the process; requiring commitment to quality becoming a part of every organization and its personnel; and assigning responsibility to all managers and other personnel to assume responsibility for the quality of their efforts. Earlier, the Department of the Navy began implementation of TQM at several of their field activities. The Naval Aviation Depot, Cherry Point, was recognized as one of the more successful productivity and quality implementations as recognized by selection by OMB as a Quality Improvement Prototype in the President's Productivity Improvement Program, winning the Institute of Industrial Engineer's Award for Excellence in Productivity Improvement, being the first to implement Productivity Gain Sharing (PGS) organization-wide, and the first to receive the Secretary of Defense Award for Excellence in Implementation of TQM.

The purpose of this paper is to (1) present the evolution of the TQM philosophy from statistical process control through artisan participation to management participation, and (2) develop strategies and detail the current model for TQM as fully developed at the DOD's leading edge organization, the Naval Aviation Depot, Cherry Point, North Carolina. Areas requiring further research are also identified.

## INTRODUCTION

Dr. Costello, Under Secretary of Defense for Acquisition, in discussing quality, stated: "I came to the Defense Department imbued with the idea of total quality management and statistical process control. I had been working with Deming for years and working with the Japanese for years. I had assumed that the aerospace people would be leaders, and I would be able to walk into the Pentagon and see moonlight and roses everywhere. I walked in and saw a conventional approach to the problem: inspections after the product is made. I could not believe it, and I was really startled. I actually saw production-line people with a hot hair-dryer type gun, the same sort of crude tooling for building composite structures that I had seen when I made such parts years ago. I saw no process and no thought on process control." Costello said that the first innovations actually occurred within the services. "I began to see improvements in - of all places - DOD depots: North Island and Cherry Point as two examples. I did not see that in the aerospace industries. I made myself understood that I did not want things to run this way. And some people understood. Martin Marietta is one that listened. In a two year time they made an about-face on the Patriot missile that is outstanding. They had reduced the re-work rate by 60 percent and their touch-labor by 40 percent. That was real progress, but I have not seen it applied across the spectrum of contractors." (1)

The Department of Defense has begun the long trek to overhaul the way it does business. The DOD has chosen not to just reorganize but to change its management philosophy to achieve the cultural transition to meet unprecedented challenges in increasing complex technologies, dramatic budgetary cuts, and requirements for substantial increases in the level of quality. This new management philosophy is named Total Quality Management (TQM). While the concept of continuous process improvement as the basic tenet of TQM is simple, yet all encompassing in [illegible] and the [illegible] environment, be it [illegible] acquisition, [illegible] evolving. Many DOD [illegible] programs have attempted [illegible] TQM to gain legitimacy for their programs, and where they fit into the tailored approach may well be the proper tools, techniques, or methodology to utilize where they make sense in analyzing the process for continuous improvement. An increasing number of U.S. companies, [illegible] are using TQM techniques [illegible] management philosophy. [illegible] are holding their First National TQM [illegible] in Denver. The purpose of this paper is to define the dynamics of TQM, discuss [illegible], and illustrate the benefits [illegible] the competitive position of an organization, be it an organization within the DOD or a member of the DOD industrial base.

## EVOLUTION OF TQM

### Statistical Process Control (SPC)

TQM has evolved from the philosophies as espoused by Dr. W. Edwards Deming and to a lesser extent by Juran, Fiegenbaum, Goldrath, Fox, and others. The beginnings involved teaching of Statistical Quality Control (SQC) techniques for process improvement. The SQC techniques have now been expanded to include problem identification and analysis techniques such as flow charting, check sheets, brainstorming, nominal group technique, Pareto charts, cause and effect (fishbone diagram), run charts, stratification technique, histograms, scatter diagrams, control charts, process capability analyses, force field analyses, and Analysis of Variance (ANOVA) techniques. Besides these techniques and tools, TQM also requires implementation of process management from definition of the processes and understanding what processes are required to process performance measures, collection of key process data and analysis of that data to determine corrective action to resolve causal factors.

### Artisan Participation

The second phase in the evolution of TQM is communications and artisan involvement to obtain continuous improvements. The Japanese began this evolution through adoption of Quality Circles that ultimately have spread to the U.S. The Quality Circle concept has now evolved to use of teaming structures in a linkpin arrangement from Process Action Teams (PATs) up through various levels of Quality Management Boards (QMBs) to an Executive Steering Committee (ESC). The interlocking multidisciplinary board/team structure to facilitate horizontal (multi-departmental) and vertical (members on a QMB that sit on the next higher QMB as well as next lower QMB) communication is shown in Figure 1.

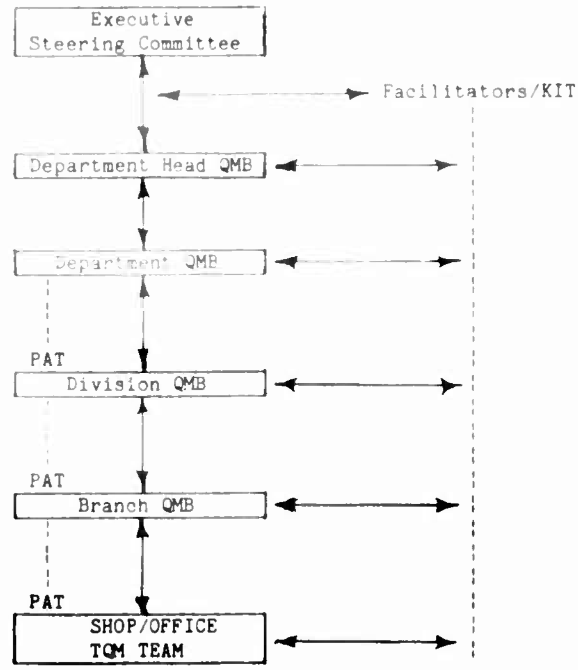


Figure 1. TQM Organizational Communication Flow

The TQM organization at NAVAVNDEPOT Cherry Point consists of the following functional elements:

- Executive Steering Committee (ESC): Committee composed of top management representatives which sets the policies to be followed and sets the policy in implementing TQM. It provides the ultimate level of support QMBs and PATs.

- Key Implementation Team (KIT): This group consists of people who facilitate TQM implementation. It performs the following functions: process control coordination, training development, organization development, documentation and measurement, and facilitator coordination.

- Quality Management Boards (QMBs): These boards are comprised of members from relevant areas, i.e., department, division, etc. They provide the organizational structure that will eliminate friction between various organizational units and enable the use of group problem-solving techniques. QMBs are permanent groups; they will not dissolve after problems are solved, but will oversee continual process improvement.

- Process Action Teams (PATs): The shop-level QMB team is comprised of individuals working on a specific issue, problem, or process. The teams are specifically formed to address a particular concern and will dissolve on completion of their work.

- Facilitators: Consists of in-house personnel selected and trained to serve as trainers and consultants to the various QMBs and PATs.

- TQM Coordinator: This individual monitors, plans, and collects information about progress and assists with administrative arrangements or whatever else may be needed to ensure implementation activities continue. This individual is responsible for implementation of policy and operational administration initiatives pertaining to the overall TQM effort, including directing KIT efforts. As implementation expands to the entire organization, this person will become more crucial.

Through this organization, the objective is to instill a feeling of ownership of the processes by not only those who work the process, but also those who manage the process. Deming continues to stress management's responsibility to (1) remove the barriers that rob artisans of pride in workmanship, and (2) weed out the attitudes that instill fear in the work place.

Management Participation

With this organization established to facilitate and intensify worker participation through a highly structured approach with activities aimed at involving everyone in the continuous improvement process, the third evolution is quite apparent: Management. TQM integrates fundamental management techniques, existing improvement efforts, and technical tools under a disciplined approach recognizing management's responsibility to manage for continuous process improvement. This represents a hard-nosed approach to participative management where managers seek input from the experts - from the artisans on the floor that know the process best to the customer who knows his requirements - and makes decisions based upon the criteria of continuous improvements in quality, cost, and schedule with the focus on increased customer/user satisfaction. TQM is a management system, a management philosophy steeped in the never-ending process of improvement. To be successful in a TQM environment, the manager must be able to obtain participation of all his subordinates in quality improvement and provide leadership to his work group through a vision of the future and commitment to TQM as it transcends his organization for the good of the company. The manager must be patient as TQM cannot be implemented overnight. The manager will find that TQM requires redesigning the measurement and reporting information systems to support TQM initiatives. In a TQM environment, the manager, while still a decision-maker, bases his/her decisions upon many more inputs, especially greatly increased analytic data. The "new" manager also assumes the role of facilitator and coordinator, assuring that everyone in the organization is fully trained not only in the skills necessary to do the job, but also in the tools of TQM and that free and open lines of communication are established with both in-house and out-of-house customers and vendors.

Recent pronouncements on application of TQM techniques and methodologies have included strategic planning as a useful tool to show management commitment to the philosophy of TQM and plan for implementation. The strategic planning process, if done properly, brings together top management within the organization to establish the mission of that organization, accomplish an environmental scan of the internal and external factors that affect the organization and plan a course of action which capitalizes on strengths and opportunities, improves on weaknesses, and attempts to nullify threats to the organization. One of the keys to strategic planning is the message it sends to mid-level managers, first-line supervisors, and artisans. It identifies what is important to top management and presents a broad view of how top management sees the business. This vision guides the everyday decisions.

Information Systems: Managing by Data

A properly designed and executed information system represents not only an integration of software and hardware but also an extension of the TQM philosophy - the desire to manage by data. This is the fourth evolution presently being discovered by corporations and government organizations alike. This fourth evolution includes measurement of complete product costs as illustrated below. To effectively manage, however, this data must be available to the artisans on the shop floor. The cultural changes inherent in TQM must also be applied to information systems philosophy. Manufacturing Resource Planning (MRP-II) and its next generation system, Computer Integrated Manufacturing System (CIMS), are the information systems which represent this marriage of TQM and information systems. Both MRP-II and CIMS are only a means to an end, to provide the capability to produce a competitive product from a competitive process based upon a competitive strategic/business plan. MRP-II integrates the production process through shop floor control, material, scheduling, quality processes, and facilities planning. CIMS adds design, analysis, simulation, and technical documentation representing the product/process design with factory automation of such functions as materials handling, assembly, inspection/test, and materials processing. MRP-II and CIMS offers an excellent opportunity to both measure productivity and quality and increase the efficient use of data for management. As processes are improved through the TQM philosophy, these improvements can be tracked for continuous improvement. MRP-II and CIMS result in more efficient and effective handling of data transactions and storage as data generation and retrieval are automated, communications enhanced, and technical and business disciplines integrated through interaction on a common system. The result should be the ability to make timely decisions by those responsible for the process based upon accurate data.

Challenging the Accountants: Managing by Cost

Under TQM, each NAVAVNDEPOT manager is involved in the budget process, allowed to negotiate cost goals, held responsible to meet or exceed these goals to reduce the cost of operation, and held accountable for the efficient and effective operation of his cost center. This includes planning for and meeting production schedules, providing production planning and control support, maintaining engineering production support, etc., while meeting cost objectives and maintaining high quality standards.

Cost center expense accounting must be overlapping. The production cost center must be required to pay for the production support, shop space, utilities, material, etc., that they use to produce their product. This allows the production managers to optimize production support required rather than demanding more services, material, shop space, or other resources without the responsibility to be charged for those additional resources. Indirect, general, and administrative expenses must be charged to the benefitting product through measurable factors and Productivity Gain Sharing (PGS) of the gains/cost reduction. Each product should be able to "break even" by bearing the full cost with valid workload standards and rates. The other coordinates of the cost matrix, the indirect cost center manager, bears no less of a responsibility to produce cost-effective and efficient quality service. Indirect expenses must be held to the minimum necessary to adequately support direct production and product engineering functions.

## Rewarding Group Results: Productivity Gain Sharing (PGS)

PGS is an employee involvement system designed to motivate employees to improve the productivity of their work group through better use of labor, material, etc. Gain sharing provides a means of measuring specific areas of productivity and offers a mutual stake in the sharing of any increase in productivity with all those responsible for the increases. The most significant gains seen in the implementation of PGS are from process improvements using the TQM philosophy. Significant increases in labor productivity and decreases in indirect material and other production indirect expenses are evident.

Before TQM and PGS, concentration by management and the artisans was directed at meeting schedule. Being the most measurable of production criteria, schedule was all important. Artisans felt that if management couldn't see the problems at the depot, that was management's problem, not theirs. The artisan could become a hero by working around the system (i.e., finding just the right part under his bench to produce an item after everyone had milled around wasting time looking for that part).

Once the linkage between TQM and PGS was understood by the artisans from the simple equation, Productivity = Output/Input, they have become concerned not only with output (i.e., schedule and quality), but also input (labor, material, support labor, and other costs). Now the hero is the artisan and/or manager who, as part of a team, suggests ideas to improve the processes, resulting in higher yields, less waste, higher quality, improved productivity, and incidentally, a higher PGS payout. Artisans are making better use of automated information tools. Managers are being stopped in the hall by workers relating problems that the artisans expect to be solved. Better teamwork is being observed between the artisans and support personnel, especially through the PAT process. Managers are working much harder as they are required to solve process problems with many more inputs. Gain sharing is driving the use of SPC for processes control, even in this job shop environment.

## TOTAL PRODUCTIVITY AND QUALITY MODEL

There are several tools or steps for productivity and quality improvement. Figure 2 illustrates these productivity and quality improvement tools for change. The basic steps are:

### Strategic/Business Planning

Technology improvements alone will not improve competitiveness. Managers have a greater requirement to focus on the business philosophies of long-term profitability and survival in the international marketplace. Strategic/business planning provides a holistic approach to establish the basis for productivity and quality improvement.

### Total Quality Management (TQM)

The centerpiece for employee participation in changes for constant improvement of productivity and quality is TQM. TQM is actually a philosophy that applies several techniques using employee involvement and participation, SPC, group dynamics, and facilitization of team-building/team interaction, and structured management commitment and involvement.

### Accounting for Productivity and Quality Improvement

That which cannot be measured cannot be managed. While SPC is one effective measurement technique, measurement of cost is the ultimate measure of productivity.

### Productivity Gain Sharing (PGS)

PGS is an employee involvement system designed to motivate employees to improve the productivity of their work group through better use of labor, material, etc. In addition, gain sharing provides a means of measuring specific areas of productivity and offers a mutual stake in the sharing of any increase to total organizational productivity with all those responsible for the increase.

As the model iterates (is cycled through) several times, a natural evolution of the changing role of artisans and managers emerges. The Strategic/Business Plan should be revisited quarterly and updated annually. TQM is implemented using a tailored set of actions and milestones; however, the purpose of these actions and milestones is to institutionalize a continuous process. Measurement is required for constant, continuous improvement. PGS should not begin until the tools for sustaining and measuring productivity and quality improvement are in place.

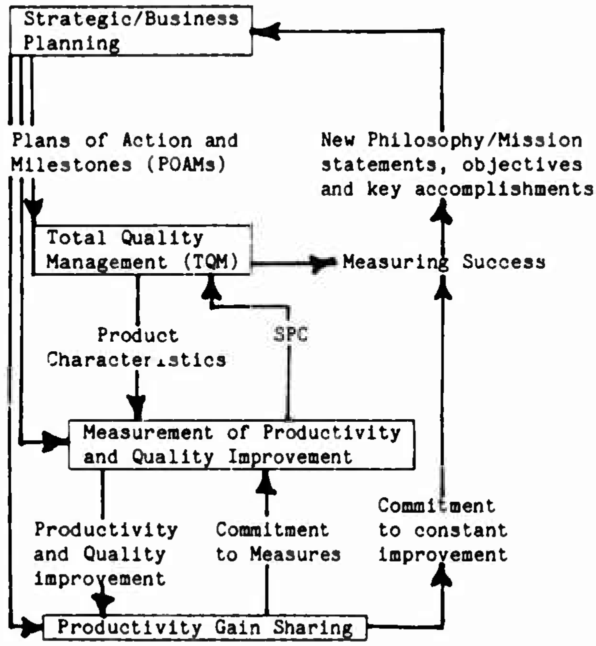


Figure 2. Productivity and Quality Improvement Tools for Change

### Developing the Productivity and Quality Improvement Model

There is a specific sequence required to obtain optimal benefits from a productivity and quality improvement philosophy. Each step builds on previous phases and provides integration between the phases and/or reinforcement of the productivity and quality philosophy. Figure 2 provides the framework for sequencing the application of the techniques and philosophies. The critical point is that an organization needs to begin by defining what is important to the operation before it begins improving productivity and quality on products which would not warrant the concentrated commitment of resources. Measurement is critical; however, what is to be measured and the techniques to be used should be driven by the strategic/business plan and SPC. PGS should not be implemented until the techniques and philosophy required for continuous improvement are implemented, measurement schemes are in place, barriers to communications are minimized and progress has been made in quality of work life, productivity, and quality improvement.

## LESSONS LEARNED FOR SUCCESSFUL IMPLEMENTATION

For cultural changes to take place as have been described - the artisan responsible for managing his own work and the manager moving to the role as facilitator and coordinator - continuous and visible top management support is essential and must focus on what is most important for our customer, improved quality. A much more participative style of management is required if the TQM efforts are to be sustained in continuous increased productivity. There must be process discipline; work must be measured objectively in terms of work packages, schedules, work content, projected costs, and expected quality output. Management, while retaining its decision-making responsibilities, must involve the work force through structured problem-solving to be part of the decision-making process. Once the decision is made, the decision-maker must be able to explain his rationale as feedback to the work force. The manager must assure that the planning efforts have culminated in a workable plan before a major project is undertaken. He must discipline himself in the new management process to assure that the resources are in place to accomplish the project and that proper progress is being made toward completion.

Top management must focus on the customer's quality requirements, support the requirement for change, and recognize the business environment they are in to provide objectives for guiding the mid-level and first-level supervision efforts. Attainment of these objectives should be structured to provide a continual improvement in the competitive position while improving the effective and efficient use of business resources. Mid-level and first-line supervisors can be collectively measured against these objectives.

Training is essential. TQM training sets the stage for required cultural changes. Key to the transition is the establishment of customer/vendor relationships within the business and the training associated with that effort. Various management courses, such as the McGraw-Hill managers/supervisors block of instruction, are ideal for teaching interpersonal skills. Much remains to be done in this area, however.

The reward system, especially selection of supervisors and managers, must be changed. Promotion cannot be based strictly on present job performance, but must fully consider the ability of candidates in interpersonal skills, management style, and an understanding of the broader picture of the business. Only after the perception changes that the promotion system policy has been transformed, will real progress be evident. Incidentally, use of SPC out on the floor may be one good measure of present job performance.

Group rewards are necessary to share the fruits of working harder and smarter. Development of a group reward incentive plan is an excellent vehicle for employee and union participation, rather than "passing the plan down from management." These plans should be developed by in-house "professionals" who are trained in the analysis and interpretation of productivity data. Work performance must be tied to the quality underpinning of the organization. PGS and TQM are based upon the same principles where PGS simply provides a reinforcement mechanism for the TQM philosophy.

Barriers to communications, both laterally and vertically, must be removed. The use of interlocking QMBs and PATs or similar teams provide structure and discipline to break down communications barriers. Total involvement of the work force by allowing everyone an opportunity to serve on PATs utilizing the knowledge and skills of the total work force and the expertise in process improvement is essential to eliminate communications barriers. The TQM process will provide the tools necessary to do their jobs better and ensure that all individuals can participate in quality improvement. It is recognized that not everyone can be involved and TQM cannot be implemented overnight, but TQM implementation requires training and everyone's commitment and participation to be fully successful.

Continuous quality and productivity improvement, strategic planning objectives, enfranchising the artisan to manage his own work, rewards as incentives, and ultimately changing the corporate culture, although requiring the leadership of top management, requires implementation at the lower levels of management. The ability of these managers to transition to new styles of participative management and their commitment and support for change is critical. The needs of these managers must be considered and incorporated into the change process. The employee involvement process <u>must</u> include these managers. Organizations must better equip first-line and mid-level managers to function successfully in their new roles. The "men in the middle" must learn to cope with increased spans of control, use new technology such as CIMS, and rely upon a participative management style for solutions. These first-line and mid-level managers are in a position to grasp the production of a particular product or service, a perspective that is often lost by upper-level managers as they are concerned with the business environment. In the day-to-day decisions made by the first-line and mid-level managers, they are often in the best position to make the changes necessary to alter the processes and eventually the culture.

## AREAS REQUIRING FURTHER RESEARCH

While some substantial research has been conducted on quality and productivity in the blue collar environment, implementation and measurement of white collar and knowledge worker quality and productivity improvement and the attendant TQM philosophy as relates to the white collar and knowledge worker environment is relatively unexplored. The primary problem here lies in identification of a measurable output and whether the outputs were even required to meet the organization's mission (measures of both efficiency and effectiveness). The three models that portray TQM as a substantial part of the productivity and quality improvement process are Sink (2), Sumanth (3), and the model depicted earlier in the paper (4). While these generalized models are applicable to the blue and white collar and knowledge worker environment, significant experience and research is required to tailor the application of the models to the white collar and knowledge worker environment. This is especially the case in the areas of acquisition and program/project management.

One area crying for quality and productivity improvement is education. If the U.S. has an Achilles Heel, it is the education process. Again, measures of quality are difficult as value added to student's knowledge (not students taught, credit hours earned, and graduates) is the real objective. Expenditures for public education has soared while the quality is often viewed as inferior. No model currently exists which measures quality improvement in education as a measure of value added nor has the philosophy of continuous process improvement been applied except in isolated cases. Significant research begs to be started in this area.

Significant research also is required in the area of organizational measurement of quality. While quality can and is measured on specific physical and performance parameters within a product (i.e., dimensional tolerances, physical properties of materials, reliability, etc.), there is not an aggregate measure. Typically, a family of criteria is used that measures defects found in-process as well as by the customer. While a simple overall performance measure is not very meaningful, measures are necessary for improvement. Initial research has been accomplished by Oden (5) on two productivity models; however, these efforts need to be extended to measures of quality. Expert systems and measurement theory as applied to quality measures offers an effective decision tool to facilitate continuous improvement. Quality measures need to be segregated into six categories: technology-based, process-based, task-based, product-based, and material-based to develop a full measure of efficiency and management-based as a measure of effectiveness.

The final area that involves significant research is the management of productivity and quality improvement. Deming defines a "master" as someone with a sound theoretical foundation, profound knowledge, wisdom and experience, skill, and conceptual and operational abilities. While there are many experts within their specific areas of specialization, there are but a few masters. Progress is severely dependent on these masters. Educational research is necessary if masters are to be created to expand and accelerate the implementation of productivity and quality improvement. New techniques and tools, such as multi-criteria quality measures, new cost accounting systems to both better record the actual costs while also improving the ability to forecast, gain sharing measurement models, especially those that measure white collar and knowledge worker contributions, and specific tailored strategies for implementation of TQM, are necessary.

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## BIOGRAPHY


Mr. John S. W. Fargher, Jr. began his career at the Intern Training Center, Red River Army Depot as a Production Design Engineer. He has held positions as systems engineer for the Small Caliber Ammunition Modernization Program (SCAMP), Frankford Arsenal; Chief of Production Planning and Control, Hawthorne, NV; Lead Engineer at Rodman Laboratory, Rock Island, IL; Chief Industrial Engineer with the Iranian Aircraft Project Manager's Field Office in Teheran, Iran; Deputy Chief of the Materiel Systems Development Division, U.S. Army Transportation School; Professor of Acquisition/Program Management at the Defense Systems Management College; Deputy Project Manager for the Light Armored Vehicle Directorate, Quantico, VA; and Head of the Production Planning and Control Department, Naval Aviation Depot, Cherry Point, NC. He completed temporary assignments as Technical Director of the Depot Operations Directorate and acting Executive Director at the Naval Aviation Logistics Center. He is currently the Management Controls Department Head and Comptroller at the Naval Aviation Depot, Cherry Point, NC.

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# THE ROLE OF TOTAL QUALITY MANAGEMENT IN THE TEST AND EVALUATION PROCESS

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**ABSTRACT**

The pitfalls of weapons procurement have provided a target for lurid headlines by journalists and a cataclysm for elected and appointed officials to aim reform. Meanwhile, our national defense strategy has not withered or wilted. Today, we seek to procure a decreasing number of highly complex weapons and defense systems, which are sufficiently software intensive and technologically advanced, so as to deter our adversary's numerically advantageous arsenal.

Yet, as successful as this strategy has been, we need to ensure that at least two of its precepts remain valid. First, the procured weapons and systems must demonstrate military utility and meet performance requirements when imperative to do so; and, second, the acquisition costs must be affordable in terms of both quality and quantity. Stated in another fashion, our national defense strategy is predicated, at least in part, on an affordable balance of the quality and quantity of military weapons and systems.

Embedded in the balance is the sensitivity and productivity of our industrial base, or more directly, the defense contractor community, to be responsive to the need for quality military products, materiel, systems and services.

## INTRODUCTION

To be sure, the Office of the Secretary of Defense (OSD) is attentive to, and has established policy to improve the quality of defense weapons and systems, the industrial base, and the military and civilian force structure. Nevertheless, to accomplish this goal, policy must be implemented by others. Certainly, the private and public sector research, development, test and evaluation communities will play a significant role in the acquisition of quality defense weapons and systems. These same communities are also of major importance to obtaining a successful implementation of total quality management principles.

In a March 1989 memorandum, the former Under Secretary of Defense for Acquisition, Dr. Costello, stated, "As a top priority, total quality management (TQM) continues to receive widespread acceptance among DOD elements and its industrial support base. Accordingly, it is now time for the test and evaluation community to embrace TQM." It can be contended that it is not the T&E community who must embrace TQM, but that it is the TQM community who should be embracing what the T&E community have been preaching for years. That is, quality weapons and systems are the result of: (1) the articulation of realistic requirements, both contractual and operational (military) user; (2) a cost effective process to quantitatively demonstrate achievement of performance requirements, while being timely, relevant, and providing balanced, yet sufficient, testing; and (3) a valid evaluation and assessment process that not only provides the basis for current performance, but also a predictive basis of weapon system success or failure.

## WHAT IS TQM?

Recently the Deputy Secretary of Defense, Mr. Atwood, stated, "Inherent in TQM is the notion that all acquisition functions can profit from a total commitment to continuous process improvement." Certainly, the T&E function has room for improvement. But to do so requires an adaptation of TQM principles to the realities of the acquisition process.

For example, the DoD commitment to TQM, as manifested in DoD Directive 5000.51, seeks to satisfy cross-functional goals of quality, cost, schedule, mission need and suitability. It concentrates on three types of measures for evaluation:

1. Process measurements - to track process performance with respect to the customer's requirements , both internal and external, and to manage and evaluate products and services;

2. Project measurements - to provide insight into the overall improvement process, and;

3. Behavioral change measurements - to provide observable, consistent evidence that TQM is being supported and is working.

To acquire these measures, TQM invokes a set of generic tools (Figure 1) that excludes T&E. So the dilemma left to be resolved is - Should T&E embrace TQM or vice versa? Actually, the omission is quite explainable, given that those fostering TQM initiatives are not always familiar with T&E nor its jargon. For, in fact, T&E uses the same tools (Figure 2), they are just referred to differently.

## APPLYING T&E TO TQM

To examine the role of T&E in the overall TQM approach, let's first look at what T&E provides to TQM. T&E provides the management foundation for obtaining and assessing truth about a systems performance in support of the decision making process. It promotes objectivity in the evaluation process by balancing point estimates and growth assessments to obtain evidence of system maturity. Through a series of checks and balances, it adds documented, verifiable discipline to the acquisition process. Lastly, the T&E process supports the acquisition process by providing sufficient amount of data to support weapon procurement decisions.

Defense system T&E is not an end unto itself. Rather, it is a crucial, synergistic and pivotal element that must maintain a balance between changing military expectations by the user and documenting credible, trustworthy results to support acquisition decisions. This balanced strategy provides the basis for real "value added" to the acquisition process. Tests should not be conducted to define quality, but rather as a modis operandi for verifying achievement of required quality levels. Continuous evaluation, beginning early in the development cycle, should be used to analyze interim test results to ensure that the products are on a maturity path that will achieve our end goal, quality defense systems that meet user requirements.

T&E is a continuum of activities interwoven within the acquisition process. Development T&E and operational T&E do not fit into rigid or discrete compartments; both are involved with broad, system-level concerns. Those engaged in weapon system acquisition need to understand the relationship of collective T&E interests that are vitally needed to support the acquisition process. The determination of when to model and when to simulate must be better understood. Additionally, modeling and simulation must be operationally verifiable and analytically flexible. In short, the purpose of T&E is to articulate an accurate and trustworthy performance evaluation of a weapon system's ability to satisfy a military utility.

## BALANCE IS KEY

T&E can play a pivotal part in the acquisition process. Certainly, under or over testing (and similar incomplete or exhaustive assessments) can hamper the utility and effectiveness needed in making timely acquisition decisions. Accordingly, test results and (product and process) evaluations must be fed back to the development community for process and/or product quality improvement, as well as, to identify ways to more effectively make use of test resources.

This is followed by T&E participation in the system engineering process. The goal of this participation is to assist in the refinement of the development process, with particular attention being paid to changes that may drive modifications to testable attributes and performance characteristics. In addition to this, for T&E activities to remain viable, we must focus our endeavors into quality efforts that produce a balanced approach to test and evaluation. An approach that recognizes the need to improve test resource utilization in light of current limitations, but continues to provide realistic and trustworthy test results to support decision-makers.

Finally, we must achieve a balance between expectations and resource limitations. This requires the T&E community to develop a culture that fosters an attitude of testing smarter and not necessarily testing more. Most importantly, this balance must continue to provide trustworthy and militarily relevant results, be they factual or predictive. We will have failed if we evade methodical verification of technical and operational performance only to have the media and congress use test data to reach a conclusion of less-than-adequate defense system performance.

The key challenge in T&E planning is to be the Monday-morning quarterback on Saturday morning. Being able to predict tomorrow's areas of technical, development or test risk are areas requiring much attention. This is particularly important since many system quality requirements reflect mature "end-point" performance levels, whereas evolutionary acquisitions with interim system configurations and performance thresholds can provide a road map to system maturity. **To be effective, a balanced T&E program must be capable of extrapolating from current technical performance (conceptual quality) levels to determine the likelihood of achieving mature operational performance (fieldable quality).**

## DISCIPLINE IS REQUIRED

The road map to system maturity is based upon the concept of an "event driven" acquisition process, where decisions are supported by events and demonstrated or confirmed through T&E. When executed completely, T&E can provide quantitative evidence of readiness to proceed forward and to the acquisition milestones. The interrelationship between system maturity and the acquisition decision process is one of the primary aspects of the Test and Evaluation Master Plan (TEMP). The TEMP is unique among defense acquisition system documents as it is the only program document currently approved by OSD. When complete, the TEMP can be utilized as a control mechanism to evaluate the program's progress through the acquisition process. As delineated in Figure 3, the TEMP is a means to provide discipline as well as management insight into the acquisition process, and to totally support TQM principles.

From a process perspective, the TEMP identifies the management structure and acquisition strategy used for acquisition. From a product and process perspective, the TEMP clearly defines the customer's requirements, translates them into measurable performance characteristics, or quality attributes, and specifies what type of data will be available to the decision making process and cost, schedule, and performance assessments.

From a product perspective, the TEMP provides the trend data and assessment mechanisms necessary to evaluate system maturity (quality) as the process and product progress through the acquisition life cycle.

Testing alone will not satisfy our needs. The accompanying process of evaluating test results and determining the degree of achievement and satisfaction of both developmental and operational requirements is the final prerequisite for balanced, quality T&E to support continuous improvement in the acquisition process. The combined T&E program must also be structured and executed in a manner that is consistent with the acquisition strategy and the information needs of the decision makers throughout the acquisition process. This requires a systematic T&E program that is responsive, valid and predictive.

## TQM and T&E INITIATIVES

In order to look at where DoD is going with both T&E and TQM, it is necessary to consider the current on-going initiatives associated with each of them. That is, one set of initiatives is concentrating on the process to improve the product, while the other set focuses on the products to provide feedback to the process.

In looking at the DoD initiatives that support TQM, it is important to note that four of the seven initiatives were individually in place long before the TQM phrase became popular. **Rather than something new, TQM is an integrating function seeking to achieve a common goal - higher quality products and services that are provided to the user (customer) on a timely basis.**

Acquisition streamlining focuses on specifying true customer requirements in terms of desired results, not "how-to-design" or "how-to-manage." Implemented by DoD Directive 5000.43, the goal is to have development and procurement organizations tailor requirements to the unique circumstances of their programs and to limit the contractual applicability of referenced documents.

Could cost is a way to get industry and government to work together to eliminate non-value added effort. It complements acquisition streamlining by adopting a contract definition approach where the contract must comply with all requirements imposed by law or executive order, but internally imposed rules, regulations, and conventions are subject to critical examination and challenge.

Transition from development to deployment requires the application of integrated design, engineering, and production (manufacturing) disciplines in the construction and conduct of defense acquisition programs. An accompanying manual (DoD 4245.7-M) uses a formal risk reduction program to support the transition process.

Industrial modernization incentive program provides incentives for contractor modernization and productivity improvement. It focuses on shared savings rewards and contractor investment protection.

Value engineering is a systematical, functional analysis that leads to actions or recommendations to improve the value of systems, equipment, facilities, services, and supplies.

Exemplary facilities is a program that will consolidate the various military services approaches for dealing with contractors who exhibit continued ability to supply superior products to DoD within the confines of their contractual requirements. A contractor who is an exemplary facility will have less government oversight.

**FIGURE 1. TYPICAL TQM PERFORMANCE TOOLS (NOTE THE ABSENCE OF TEST AND EVALUATION)**

- BENCH MARKING
- CONCURRENT ENGINEERING
- DESIGN OF EXPERIMENTS
- TEAM BUILDING
- QUALITY FUNCTION DEPLOYMENT
- TIME MANAGEMENT
- CAUSE AND EFFECT DIAGRAMS
- COST OF QUALITY

INPUT/OUTPUT ANALYSIS

- NOMINAL GROUP TECHNIQUE
- STATISTICAL PROCESS CONTROL
- WORK FLOW ANALYSIS

**FIGURE 2. TYPICAL TQM PERFORMANCE TOOLS — A T&E PERSPECTIVE**

- BENCH MARKING
  - STRATEGIC T&E PLANNING
- CONCURRENT ENGINEERING
  - COMBINED DEVELOPMENT AND OPERATIONAL T&E
- DESIGN OF EXPERIMENTS
  - TEST DESIGN
- TEAM BUILDING
  - TEST PLANNING WORKING GROUPS (TPWGs)
- QUALITY FUNCTION DEPLOYMENT
  - BASELINE CORRELATION MATRIX
- TIME MANAGEMENT
  - TEST SCHEDULING
- CAUSE AND EFFECT DIAGRAMS
  - TEST ANALYSIS
- COST OF QUALITY
  - TEST RESOURCE BUDGETING
- INPUT/OUTPUT ANALYSIS
  - TEST PLANNING
- NOMINAL GROUP TECHNIQUE
  - TPWG ACTION GROUPS
- STATISTICAL PROCESS CONTROL
  - TREND ANALYSIS
- WORK FLOW ANALYSIS
  - TEST PLANNING

**FIGURE 3. HOW THE TEMP CAN IMPLEMENT TQM**

THE TEMP IS THE IDEAL APPROVAL DOCUMENT TO:

- IDENTIFY MANAGEMENT CONTROL STRUCTURE
- DEFINE CUSTOMER AND SYSTEM PERFORMANCE REQUIREMENTS
- DELINEATE OPERATIONAL AND TECHNICAL PERFORMANCE CHARACTERISTICS (QUALITY ATTRIBUTES)
- INTEGRATE DATA AVAILABILITY WITH THE SCHEDULE FOR:
  - MANAGEMENT DECISIONS
  - COST, SCHEDULE AND PERFORMANCE ASSESSMENTS
- PROVIDE TREND DATA FOR SYSTEM MATURITY (QUALITY) ASSESSMENT

Product nonconformance reduction is a policy that focuses on actions to be taken early in the design, development, and production of new systems, subsystems, and equipment in order to prevent nonconformance (material review board action on Type II quality deficiencies. The objective is to reduce costs and delays incurred from rejecting contractor products by setting objectives for contractors to reduce or eliminate nonconformance and promote continuous quality improvement.

T&E initiatives include: DoD policy Directive 5000.3, "Test and Evaluation," update; DoD 5000.3-M-1, "Test and Evaluation Master Plan (TEMP) guidelines," revision; DoD 5000.3-M-5, "Procedures Manual - Improving Test and Evaluation Effectiveness in Support of the Major Systems Decision Process, Volume I - Planning Development Test and Evaluation for Operational Relevance" publication; and the Defense Science Board summer study, Improving Modeling and Simulation to Improve Test and Evaluation Effectiveness in Support of the Defense Acquisition Process.

## SUMMARY

Quality test and evaluation is an effective, efficient balance of: complementary testing, at the component and subsystem levels; growth testing, model utilization, appropriate simulations and environment tests; and compliance stress and operational testing. The goal of quality T&E is to provide substantiated evaluations and unbiased assessments. The defense acquisition community will be reformed when <u>quality test and evaluation becomes synonymous with quality systems</u>.

Meanwhile, T&E must be an integral element of any effective TQM strategy. They are not mutually exclusive events. T&E must bring realism to the affordability, executability, and system performance/effectiveness assessments vital to acquisition decisions.

# CONTRACTING

# CONTINGENCY CONTRACTING: THE DARK SIDE OF THE COIN

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## ABSTRACT

Results of a recent study have confirmed that contracting officers, required to procure goods and services to support a deployed force during contingency operations, simply do not have sufficient authority to adequately perform their function within all laws and regulations.

Present government acquisition regulations do not cover these low intensity conflicts which are defined here as synonymous with undeclared war. To strictly follow the FAR and applicable statutes, a contracting officer in such a situation has no other real choice but to supply the troops, operating as close to the law as possible, yet realizing that he may be subject to subsequent censure.

Foreign cultural considerations may be paramount in contingency contracting. Four such cultural differences are defined and discussed. Unfortunately, the statutes and regulations do not provide these and similar problems to be taken into account by the contingency contracting officers.

Although this is not a new problem, it is only recently that solutions have been advanced. Some partial relief has been authorized. The Department of Defense has recently (April 1988) forwarded to Congress recommendations for modifications to the FAR and for certain statutory changes. These recommendations will be discussed.

With or without prompt and positive action on these proposals, the need for educating acquisition personnel in contracting during contingencies is manifest. While DOD is concerned now with "normal" peacetime and wartime contracting, surprisingly no course or training exists in contingency contracting. Yet these situations are more likely to occur than full scale war. It is suggested this type of education be initiated within DOD.

## INTRODUCTION

The past forty years have seen many dramatic changes in our Nation's military policies and strategies, not the least of which is the success of "nuclear deterrence" in preventing all out global war. Its very success in limiting declared and undeclared warfare to regional or even local conflicts has raised a problem which has been addressed only recently.

Supplying the troops in limited conflicts becomes difficult if not illegal under a procurement system developed for large scale global warfare. Forces ranging from a simple assault team to a larger, unified body of troops engaging in an overseas contingency operation often require on-the-spot purchase of war materiel. Time limitations, extended supply routes, secrecy, unavailability of the required item in the pipe line, etc., all may necessitate that overseas local purchases be made quickly and with a minimum of red tape.

Recent studies[1 have shown that during these limited combat situations, i.e., contingency operations, the procurement official must often choose between jeopardizing the mission and violating the law. This untenable situation has only recently been partially addressed and some ameliorative measures taken through statutory and regulatory amendments. These may provide half of the solution. The other half must come by educating DOD procurement officials in the general commercial environment and specific business practices and customs found in the overseas country where the contingency operation may be undertaken. While obviously the exact location of future contingency operations cannot be pin-pointed, the broad regions can be predicted with some credibility and overviews of these subjects presented in a classroom situation.

The terms contingency and contingency contracting have been recently defined and added to the Department of Defense Dictionary of Military and Associated Terms[2.

> *Contingency*: An emergency involving military forces caused by natural disasters, terrorists, subversives, or by required military operations. Due to the uncertainty of the situation, contingencies require plans, rapid response and special procedures to ensure the safety and readiness of personnel, installations and equipment.
>
> *Contingency Contracting*: Contracting performed in support of a peacetime contingency in an overseas location pursuant to the policies and procedures of the Federal Acquisition Regulation System.

An analysis of the definition of contingency contracting as it stands reveals one of our newest oxymorons. Contingency Contracting Officers (*CCO*) cannot always successfully perform contingency contracting and abide by the Federal Acquisition Regulation. This has been confirmed by JCS studies and in detail by a recent Air Force Institute of Technology study of experienced United States Air Force Tactical Air Command CCO's[3. With anonymity pledged to "protect the guilty", those CCO's interviewed, ranging in present rank from SMSgt to Colonel, were unanimous in pointing out to the interviewer that there has been no policy guidance for the CCO's to follow during overseas contingencies except to support the deployment force. The "how to's" have, perhaps intentionally, been left vague or undefined.

The CCO's all pointed out that existing regulations and statutes do not suffice, as they are geared to wartime or peace time mass mobilization or at least to a high state of readiness for full scale conflict. As will be seen below, even the waivers and alternatives to these situations are limited to declared emergencies or war, yet military strategists agree that undeclared contingencies or low intensity conflicts pose the greatest threat to the United States in the near future.

Tomorrow's successful contingency contracting will require efforts today toward appreciation of the cultural and commercial realities of the local marketplace; statutory and regulatory changes, a policy commitment to protect the CCO; and the education of present and future CCO's in the customs and laws, both domestic and foreign, which delineate the realities of the CCO under fire.

It would be difficult enough for a CCO, under emergency conditions, to perform his mission efficiently even in the domestic marketplace. At home, the CCO is at least familiar with the three main areas of language, customs, and business practices which partly define the contractor's attitudes and actions in a commercial exchange. Some overseas locations in which the CCO's may find themselves might have customs and business practices similar to those of the domestic market. South Africa and some of its adjacent areas come readily to mind. Still, even there, the spoken accent would mark the American CCO as a patent outsider. But how about Japan, Korea and China (all Oriental but each decidedly different in all three components), Islamic countries, even Western and Eastern Europe? May a CCO presume that contingency contracting would be business as usual in the American tradition? Hardly. The AFIT study[4] revealed four areas which illustrate the problem vividly.

*Unacceptable Clauses*: Many clauses required by the FAR contain dictation unacceptable to foreign governments and foreign contractors. For example the word "sovereign" is used in referring to the United States in certain required clauses, including Disputes and Examination of Records. Other governments feel they are equal to, not subordinate to, the United States and object to the use of this term. Similarly, on-the-spot cash payment may be a violation of the FAR, but may be required by the foreign merchant. What choice should the CCO make: obey or pay?

*Favoritism and Competition*: The American attitude that the low bidder gets the contract is not universal. The CCO's interviewed reported that negotiation with several contractors at one time is simply not done in some cultures. Prior satisfactory performance or the right political contacts may make a contract award mandatory to favored contractors regardless of price. Failure to do so may lead to no performance by anyone else because of fear of local retribution or other consequence. Payola may be a local requirement for performance. Barter of one item for another may also be a local requirement. These are FAR violations to be sure, but how else to accomplish the mission?

*Language and Written Contracts*: Every CCO interviewed complained of problems getting foreign contractors to sign documents. Often a handshake or one's word is considered sufficient, and insistence on the FAR requirement of a contract in writing (or written documentation of a contractual agreement) is insulting to the foreign contractor. The problem is further complicated when a foreign contractor cannot read English. Contractors are often fluent enough in spoken English, or the CCO may be fluent enough in the local language to agree on a verbal contract, but neither can understand enough of the other's written language to sign something they cannot read and fully comprehend.

Another problem in this area is simply the impossibility of getting a document typed or reproduced in sufficient copies to meet the FAR requirements. A Canadian attorney reported[5] several years ago that negotiating a very complex contract for a major construction project in a West African country was simple compared to finding one Xerox machine in working order in the entire country.

*Time*: Time has a relative definition, depending on the contractor's subjective perception of its passage. We are all familiar with the different perceptions of "time" throughout the various regions of our own country. These differences may be highly magnified in foreign cultures. The old song "Manana, Manana, It's Good Enough For Me" is illustrative of the CCO needing supplies right now and the foreign contractor's attitude of "if not today, then tomorrow or the next day." This was reported to be not only frustrating but highly detrimental to mission performance. It is easy to imagine thoughts of immediate confiscation at gun point.

Present and potential CCO's knowledge of these four as well as other cultural differences and an awareness of their implications for successful mission completion by legislators and policy makers alike could help foster acceptable solutions to this problem of legal contingency contracting.

**Statutory and Regulatory Amendments**

There are several present and several proposed waivers and changes to the procurement statutes, FAR and Defense Federal Acquisition Regulation Supplement (*DFARS*).

The present statutory waivers to the rigid procurement statutes mandated by Congress for full scale wartime or peacetime mobilization are unfortunately limited to situations which do not help in contingency situations. The *Defense Resources Act* (50 U.S.C. § § 1431-1435) permits the President to waive many procurement laws in the event of a declared national emergency.

The *NATO Mutual Support Act* (P.L. 96-323) authorizes the Secretary of Defense to waive many procurement laws when contracting with a host government.

These statutes help alleviate some of the CCO's problems discussed within but contain three significant and stultifying conditions: the first statute mentioned requires a declaration of national emergency, yet most contingency operations will precede any such declaration. The second statute is limited to NATO signatories, hence of no operative use in other parts of the world; as amended it only applies to contracts with NATO and other host governments, not contracts with private contractors. Thus it offers no help at all in a Nicaraguan-type situation.

The Office of the Joint Chiefs of Staff has recently promulgated and forwarded to the DAR Council and to Congress several proposed changes in the FAR and certain procurement statutes[6]. These changes, if implemented, would solve many of the non-cultural problems present today. The major piece of legislation proposed, tentatively entitled the *National Emergency Procurement Act*, is intended "to amend inappropriate requirements in procurement laws for the period of a declared national emergency or contingency" by relieving the DOD of "the burden of normal procurement practices which are irrelevant and detrimental to the national security situation during a [contingency]."

The proposed statutory changes include amending the *Competition in Contracting Act* (10 U.S.C. § 2304 (g) and 41 U.S.C. § 253); increasing the small purchase threshold from the present "not to exceed $25,000.00" to $100,000.00 during a contingency as declared by the Secretary of Defense; modifying submission of cost and pricing data requirements under the *Truth in Negotiations Act* (10 U.S.C. § 2306 (h) from a threshold of $100,000.00 to $500,000.00; and limiting the cost or pricing data required to that sufficient for contracting officers to determine fair and reasonable prices.

Those changes proposed in the procurement regulations include: revising DFARS Section 13.505-3 to raise the maximum small purchase procedure ceiling when a C.O. uses SF 44 procedures; and, revising DFARS Section 13.404 to provide for a ceiling of $2,500.00 when using the Imprest Fund procedures. Both of these regulatory changes would be triggered by the declaration of a contingency by the Secretary of Defense.

**Possible other Changes:**

The authors here suggest several other changes which they believe are necessary to make contingency contracting successful and yet protect the CCO. Whether it involves the President declaring a national emergency (and we have heard of the possibility of a predated document or a document kept secret for security purposes), or the Secretary of Defense declaring an emergency, the level of authority required to enervate contingency contracting is too high and may result in a delay or in no declaration, thus providing no protection for the CCO in the field.

The present procedure for the declaration of a contingency is perhaps politically palatable but seems operationally reversed for most contingencies. At present the request for such a declaration[7] goes up the chain of command from the Commander of a combatant command, through the Commands J-4 to the Chairman, JCS. The Chairman, JCS, reviews and forwards it to the Secretary of Defense who, upon approval, transmits the declaration back through the Chairman, JCS, to the CINC, to the component commands.

The authors feel that any initiation of a contingency operation in today's environment would have the President's, or at least the Secretary of Defense's, prior knowledge and authorization. Therefore, the Combatant Commands' CINC should have authority to issue a *written* command that contingency contracting procedures may immediately be implemented. This would eliminate unnecessary bureaucratic input and minimize the unnecessary loss of valuable time. Each CCO should be authorized, under contingency contracting conditions, to deviate from certain FAR and statutory requirements in the theatre of operations under a DOD policy statement, in writing and communicated to all present and future CCO's -- that all CCO's must do their utmost under the contingency conditions to follow the FAR and all the existing laws and regulations but that their primary mission is to support the deployed force in the best method and manner legally practicable in carrying out their stated duty. Each CCO may then be judged by his or her actions under the circumstances and shall carry the American legal presumption of innocence if a law or regulation is broken during the exigencies of a particular situation.

Each interviewee in the AFIT study[8] expressed the view that such a written policy is the number one requirement needed for successful contingency contracting. It must be assumed that it would be in the national interest to relieve the stress generated by the CCO's present "Hobson's Choice" and allow the CCO the presumption of legality granted all of our fighting forces when ordered into battle.

Implementation of all of these proposed and suggested solutions are necessary to bring contingency contracting to the same level of professionalism attained by the general procurement community. Specialized education is required. We therefore propose that DOD, in addition to the implementation of the changes already generated and those suggested in this paper, institute immediately a short course in Contingency Contracting containing the legal requirements and the cultural and commercial considerations inherent in contingency contracting. The School of Systems and Logistics at AFIT could develop such a course given the faculty's specialization in government contract law, contract administration and combat logistics. We ask for your support.

## Notes

1. See J.C.S. Memorandum for the Director, DAR Council, dated 12 April 1988 (J4M-256-88) and "Contingency Contracting During Low-Intensity Conflicts," Mason, Captain Robert L, (Master's Thesis) Air Force Institute of Technology, WPAFB, Ohio, 1988.

2. JCS Pub 1.

3. See Mason, 1988, *supra*.

4. See Mason, 1988, *supra*.

5. Anonymous personal communication to John W. Garrett, 1984.

6. Legislative proposal forwarded to Congress. See J.C.S. Memorandum J4M-256-88, Enclosure D, cited in note one above.

7. Legislative proposal forwarded to Congress. See J.C.S. Memorandum J4M-256-88, Enclosure B, cited in note one above.

8. See Mason, 1988, *supra*.

# Uncompensated Overtime: Is It in the Government's Best Interest?

**by Robert E. Bauder, CPCM**

One of the objectives of the Government procurement system is to be fair and equitable to all potential suppliers of goods and services. To ensure objectivity, the Government has, to a much greater extent than the private sector, used price as the primary basis for award. Under certain types of contracts (e.g., CPFF, T&M, etc.), the evaluated price can differ significantly from the amount the Government eventually pays for the services. Under these types of contracts, contractors are motivated to present the lowest possible cost to the Government for evaluation purposes. One technique companies utilize to present the lowest possible cost is known as uncompensated overtime.

Uncompensated overtime, also known as full-time accounting, deflated hourly rates, or an extended work week, is the term used when companies record all hours worked, including those in excess of eight hours per day or 40 hours per week, for salaried professional employees, those exempt from the Fair Labor Standards Act; e.g., engineers. In order to be more competitive, many companies propose direct labor rates that are less than the normal calculation of an hourly rate (annual salary divided by 2,080 hours). For example, if an individual typically works an average work week of 48 hours, in lieu of 40 hours, the company proposes an hourly rate that is adjusted downward as shown in Table 1. This procedure gives the appearance of a lower hourly rate even though the individual receives the same salary.

The uncompensated overtime adjustment, which lowers the hourly direct labor rate, is uniquely advantageous in the engineering and technical services arena because the Government almost always specifies the number of hours it expects to utilize. Therefore, with the hours being fixed for bidding and evaluation purposes, the lower hourly rate provides the company which utilizes uncompensated overtime with a significant pricing advantage even if salaries and overhead are identical to a competitor.

If uncompensated overtime is a new concept to Government personnel involved in the technical and engineering services arena, it indicates a weakness in the Government's cost analysis methodology. In determining the basis for the proposed direct labor hourly rate, the Government should be interested in reviewing the annual salary, in addition to the hourly rate. Review-

**TABLE 1. CALCULATION OF HOURLY RATES**

**Standard Method**

Annual Salary ÷ 2,080 Hours = Hourly Rate

| | |
|---|---|
| $41,600 ÷ 2,080 hours = | $20.00/hour |
| Overhead, G&A, etc. (@ 100%) | 20.00 |
| Profit (@ 10%) | 4.00 |
| Fully Burdened Hourly Rate | $44.00/hour |

Billable amount for a person year = 1,856 hours X $44/hour = $81,664

**Uncompensated Overtime Method**
(Assuming an average 48 hour work week)

Annual Salary ÷ Actual hours to be worked plus vacation/holiday/sick time, etc. = Hourly Rate

| | |
|---|---|
| $41,600 ÷ 2,496 hours = | $16.67 |
| Overhead, G&A, etc. (@ 100%) | 16.67 |
| Profit (@ 10%) | 3.33 |
| Fully Burdened Hourly Rate | $36.67/hour |

Billable amount for a person year = 2,227 hours X $36.67/hour = $81,664

NOTES

(1) 1856 hours is based on 2080 hours minus 224 hours (5.6 weeks) for vacation/holiday/sick.

(2) 2496 hours is based on 52 weeks times 48 hours per week.

(3) 2227 hours is based on 2496 hours minus 269 hours for vacation/holiday/sick.

ing the annual salary provides a better comparison among various offerors, as well as insight into the offerors personnel management practices. Either during audit or as a part of the cost proposal instructions, the Government should request the number of hours that the salary is divided by to determine the hourly rate.

The impact of uncompensated overtime is distinctly different for T&M contracts versus CPFF contracts. Under T&M contracts, the contractor is entitled to invoice for all hours worked under the contract. This could include not only the hours expended in the contractor's facility during normal working hours but also time spent in a travel status (e.g., evenings and weekends), time for unsupervised work at the employee's home, or even driving to and from work assuming the individual was performing functions directly related to the contract.

Unlike the standard practice of recording eight hours on the time sheet per day and forty hours per week (even though some additional hours may have been worked), the contractor with an uncompensated overtime accounting system now invoices the Government at the rate set forth in the contract for all hours worked, perhaps 48 or more hours per week for some employees. Once a contract is signed, the contractor must insist on having the employees work the additional hours consistently in order to recover their salaries, as well as the contractor's cost and profit. Therefore, the attractive, low hourly rate that helped the contractor win the contract is now multiplied by something more than 40 hours per week. Due to the additional hours (those in excess of 40) being charged, the weekly cost per person charging to the contract may no longer be the "bargain" price that the bid rate per hour implied. The lower hourly rate gained by dividing the salary by a number greater than 2,080 hours must now be recorded on time sheets and billed to the Government at the same projected overtime rate (e.g., 48 hours per week) in order for the contractor to earn the proposed profit rate. In addition to the contractor's motivation to work the employees for the longer work week that was factored into the rate, there is a further motivation to work the employees additional hours - the entire hourly billing rate for these hours is all profit (all salaries and overhead expenses have been recovered from the first 48 hours).

Table 2 demonstrates that the contractor must provide incentive to the professional employees to work uncompensated overtime or else the company will lose money.

**TABLE 2. ANALYSIS OF CONTRACTOR'S PROFIT USING UNCOMPENSATED OVERTIME**

| Average Work Week | 40 hrs. | 48 hrs. | 56 hrs. |
|---|---|---|---|
| Billable Hours per Year | 1,856 hrs. | 2,227 hrs. | 2,598 hrs. |
| Revenue ($) | 68,060 | 81,664 | 95,268 |
| Cost ($) | 74,240 | 74,240 | 74,240 |
| Profit ($) | (6,180) | 7,424 | 21,028 |
| Profit (%) | (8.3) | 10 | 28.3 |

NOTES

(1) Contract Rate/Hour = $36.67

(2) The revenue varies based on hours recorded and invoiced. The cost remains constant because, by definition, the additional hours are "uncompensated."

(3) Billable hours per year equals hours per average work week times 46.4 weeks. 5.6 weeks are non-billable (e.g., vacation/holiday/sick time)

(4) Revenue equals hourly rate times billable hours per year

Although the uncompensated overtime may be considered voluntary by the contractor, it becomes mandatory in practice because the contractor cannot stay in business without working these hours. The windfall profit that results from working extremely long hours is ripe for abuse as demonstrated from a recent article in the Newport (R.I.) Daily News:

> "A. Ted Mollegen, president of Analysis and Technology of Stonington, Conn., said the newly instituted practice has already led to 'creative cheating' by some contracting firms.
>
> For example, an individual may apply for a job at a local contracting firm that has offices in two different communities. The firm hires the individual but assigns him to work in its second office, about an hour's drive from his home. Then it gives him a temporary assignment in his own community, but because he is technically assigned to the other office, he can claim one hour's travel time. The worker will not be paid more, and in fact, is not traveling at all, but the company will credit him with one hour's travel time and log it under uncompensated overtime.
>
> In a second scam, a company institutes an on-call system to make sure someone is available

to work if an emergency should arise. An individual is told he must be available to work on Saturday if needed and therefore cannot leave town. He may even be issued a beeper. The individual is not called on Saturday. But the company credits the individual with eight hours of uncompensated overtime.

Mollegen said these scams are not easily discovered. And, if they are, the company could claim it was legitimately logging the time 'in good faith,' since the concept of uncompensated overtime is still vague. 'A company that does that is sending a message to its employees that 'we want you to cheat,'' Mollegen said. 'I have a concern about a straight-hour workweek. Inherently it encourages an employee to cheat. He's working his number of hours whether there's a need or not. When people do start to cheat, eventually we'll have a scandal. And that will be bad for everyone.'"

As the work week lengthens, the Government should evaluate:

(1) the value of these additional hours (at some point productivity must decline),

(2) the impact of talented scientific and engineering personnel leaving the defense industry to return to a normal work week,

(3) the lack of surge capability to handle peak periods (the ability to obtain quality work from employees who have continuously worked substantial overtime hours is impaired), and

(4) the ability of the Government, including the associated cost, to monitor contractors in order to avoid situations that would lead to fraud, waste, and abuse.

As the work day is extended, contractor's management personnel may not be available to ensure that the work is performed in the most cost effective manner. In fact, the windfall profit available through working longer hours is motivation to perform in a less efficient manner on Government tasking - the hours an individual works beyond those bid represent 100% profit to the contractor.

To illustrate the problem with uncompensated overtime under T&M contracts, the following example is presented:

> The Government RFP calls for 300 person-years of professional services. The RFP specifies various labor categories with the sum of the hours equaling 556,800 hours.
>
> Offeror A proposes an average rate per hour of \$36.67/hour (based on a 48 hour work week, as shown in Table 2)
>
> Evaluated total price - \$20,417,856 (\$36.67/hour X 556,800 hours)
>
> Offeror B proposes an average rate per hour of \$44/hour (based on a 40 hour work week)
>
> Evaluated total price - \$24,499,200 (\$44/hour X 556,800 hours)

Assuming approximately equal technical scores, the Government selects Offeror A expecting to realize a savings of more than \$4 million. However, during the evaluation, the Government did not consider the cost per person-year. Had this been analyzed the results would have shown:

> Offeror A:
>
> Net productive hours/year X hourly rate - billable amount per person-year
>
> 2,227 hours/year X \$36.67/hour - \$81,664/year
>
> 300 person-year billable amount - \$24,499,200
>
> Offeror B:
>
> Net productive hours/year X hourly rate - billable amount per person-year
>
> 1,856 hours/year X \$44.00/hour - \$81,664/year
>
> 300 person-year billable amount - \$24,499,200

What appeared to be a \$4 million savings or 20% ends up costing the same or more than the unsuccessful offeror's cost of performance. Depending on the technical scoring, the Government may not have made the "best value" selection.

Not only does uncompensated overtime go undetected during the evaluation phase, but also during performance. The Contracting Officer's Technical Representative (COTR) may not be aware of the contractor's use of uncompensated overtime. Most certificates of performance or invoices contain summary information showing hours by labor category incurred for the month. The contractor is not required to disclose how many of these hours were worked over and above a forty hour work week. Knowing the Government is not aware of the amount of uncompensated overtime worked, the contractor is further motivated to exploit the situation because of the windfall profit opportunity.

The consequences of this approach include expending the hours and/or funds prior to the end of the contract period and the Government being faced with either funding additional monies and hours to continue the services or do without the services. Also, even if the contractor adjusted for the accelerated number of hours being incurred by hiring fewer people, the Government would be impacted by not having the surge capability during peak periods to have additional hours absorbed by the existing staff. The Government would have the additional surveillance responsibility, including the Government's in-house cost, of monitoring the contractor's performance to ensure the work is being performed in a cost-effective and efficient manner and to ensure additional hours are not being charged that would be of minimal value to the Government but would substantially supplement the contractor's profit.

Under CPFF contracts, the Government only gets billed for costs incurred by the contractor. Since the contractor's professional employees are not paid for these uncompensated hours, there is no cost passed on to the Government. Under CPFF contracts, the major concern is to prevent one contractor from benefiting from an evaluated low price by promising a significant number of "free" hours that may not be subsequently delivered. Since contractors are entitled to be reimbursed for their actual cost incurred, there is incentive to be more aggressive in their projection of actual hours to be worked than under a T&M contract. Under the T&M contract, the contractor must actually work the projected hours to recover the employee's salary.

The solution presented below is within the framework of the Congressional language contained in the DoD Authorization Act -- FY 1989 which states that DoD will establish criteria to ensure that proposals for professional and technical services are evaluated on a basis that discourages contractors from proposing mandatory uncompensated overtime for its employees.

The RFP clause proposed in Table 3 (which has been used in several U.S. Navy solicitations) would take away any unfair advantage gained by proposing rates that are based on uncompensated overtime. Accordingly, once the practice was eliminated, the responsibility for the Government to more closely monitor the contractor would also be eliminated. Until agencies incorporate this clause, it would be prudent to evaluate uncompensated overtime under both cost realism provisions and the Evaluation of Compensation for Professional Employees (FAR 52.222-46).

The Government, as a prudent buyer, should know the answers to the following questions prior to the award of a major service contract:

- o Does the contractor pay its professional staff for hours worked in excess of forty hours per week ?
- o Does the contractor record and, in turn, invoice for hours worked by its professional staff in excess of forty hours per week ?
- o What is the average work week of the contractor's professional staff ? If it exceeds forty hours, is this factored into its billing rate ?
- o Does the contractor, by company policy, require professional employees to work in excess of forty hours per week and is this factored into its billing rate ?

The answers to these questions are critical in the source selection process, both to insure that the Government understands what is being bought and to provide the contractor community with the confidence that they are being evaluated on an equal basis.

**TABLE 3. RFP CLAUSE USED BY THE NAVY TO ELIMINATE THROUGH THE USE OF UNCOMPENSATED OVERTIME.**

*L-21. WORK WEEK AND UNCOMPENSATED LEVEL OF EFFORT*

*(a) Except as provided for in paragraph (b), it is required that proposed direct labor rates for all direct labor categories be based on the division by 40 of each employee's weekly salary, or average weekly earnings, to represent a normal 40-hour work week and that overhead rates and other costs be based on employees working a normal 40-hour work week. This requirement also applies to subcontractors whose effort is included in the proposed level of effort.*

*(b) The Contractor may include uncompensated effort in his proposed level of effort if*

the requirements of paragraph (c), below are met. The decision to propose hours in excess of eight hours per day and/or 40 hours per week for employees who are exempt from the Fair Labor Standards Act (FLSA) is the offeror's decision. Should the offeror elect to propose such hours, the rates proposed shall be "weighted" by the hours in excess of 40 hours per week for employees not subject to FLSA (e.g., 50 hours of effort that would be billed on a 40 hour per week basis at $10.00 per hour should be converted to $8.00 per hour).

(c) If the Contractor decides to include uncompensated effort in his proposal, the following requirements must be met:

(1) The Contractor has an established cost accounting system, approved by the Defense Contract Audit Agency, which records all hours worked, including uncompensated hours, for all employees, and regardless of contract type. Failure to meet this requirement may result in the proposal being removed from consideration for contract award.

(2) Uncompensated hours, for all employees and regardless of contract type, are included in the Contractor's base for allocation of indirect costs and meet the requirements of CAS 413.

(3) The proposal identifies hours of uncompensated effort proposed by labor category.

(4) The proposal identifies the amount of uncompensated effort which will be performed without supervision and without support personnel and assesses the productivity of such effort.

(5) The proposal describes the extent to which employees are required or encouraged to perform uncompensated effort and the impact the use of uncompensated effort has on work effectiveness.

(6) The proposal includes a copy of the corporate policy addressing uncompensated effort.

(7) The proposal includes a separate, complete cost breakdown, to the same level of detail as the breakdown supporting the cost proposal, which is based on direct labor rates for all direct labor categories based on the division by 40 of each employee's weekly salary, or average weekly earnings, to represent a normal 40-hour week and is based on overhead rates and other costs based on employees working a normal 40-hour work week. It is this cost breakdown which will be used to perform the Cost Category Evaluation.

(8) The requirements stated in (1) through (7), above, must be met for each subcontract which has uncompensated effort included in the proposed level of effort.

# ACQUISITION PROCESS/ METHODOLOGY

ACQUISITION PROCESS/METHODOLOGY

ACQUISITION RESEARCH: THE PAST IS PROLOGUE

Robert R. Judson, The RAND Corporation

ABSTRACT

There needs [illegible] thorough examination of the objectives [illegible] of acquisition research sp[illegible] performers in order to come to terms [illegible] state of acquisition research needs and results.

INTRODUCTION

The purpose of this paper is to suggest a check list for s[illegible] examination.

The first se[illegible]ers necessary tools of research; the second identifies responsibilities for research in the Executive Branch, and the final section is a call for specific acquisition research in the area of major systems acquisitions.

(Text of Paper)

"If you don't know where you are going, any road will do!"

Acquisition Process Model

Past acquisition research projects may claim, with some justification, the use of scientific method in addressing their research objectives.

However, at a conceptual or management level, there is no detailed narrative and graphic depiction of the acquisition process which might represent a compass for the researcher or a context for research products. Without such a model, the interdependencies and interrelationships of key acquisition concepts and issues often are not seen or acknowledged in the research process. This omission dooms the utility of the research product.

Absent such a model, there is no way to measure an evolving research product for its potential impact on the acquisition process, or vice versa. Most research products are presented on a stand-alone basis and, consequently, of minimum value to the acquisition practitioner who should always consider the entire acquisition process span. The researcher has no context to guide research activity. The issue of integrating the research results into the acquisition process never is addressed.

Index

Closely related to the absence of a conceptual model of the acquisition process is the absence of any sort of universal index for organizing acquisition information.

A consensus on such an index is essential for the useful organization of libraries, authors, instructors, and researchers to handle the literature dealing with acquisition. Such an index would be a natural derivative from the conceptual model suggested above.

Acquisition management doesn't have a "corporate memory," in large part because there is no consensus on how to organize acquisition information.

Anyone who has tried to use FLITE (Federal Legal Information Through Electronics) or the usual key word index for compilations of acquisition information, or even commercial indexes such as CCH, Government Contracts Reporter, knows what a frustrating process it is to wade through these separate, parochial, unreconciled indices.

Each major data base has its own index. None of the indexes are coincident, and there is no way to link one data base to the next.

In order to perform contemporary acquisition research, one must rely heavily on individual knowledge of relevant materials. There is no thoughtful, universal index to help unlock data base information.

## Lexicon

In addition to the absence of a conceptual model or useful index, we lack a standard lexicon of key words and concepts in the context of an acquisition process model.

Efforts are made, repeatedly, to propose a useful consensus on as few as 25 or 30 keywords and concepts. These are usually thesis efforts by students who started out on other thesis topics, but reacted to the absence of research tools as noted in this paper. Taking "first things first," they ended up addressing the need to agree on working definitions for basic concepts with which, supposedly, we deal each day, but which have not been ordered in a way consistent with the conceptual model or indexing needs suggested above, and without which their initial research efforts were blocked.

The slick, abbreviated, self-satisfied, all-purpose definitional summaries that make the rounds, some with the imprimatur of DOD training activities, not only miss the mark, they actually subtract from useful understandings that do exist in the area.

Let the reader test the need in this area, dwell on the concept of "competition" in the acquisition process, then reach for the existing definitions of "competition" in any "authoritative source" which provides a conceptual orientation, distinguishes design competition, price competition, life cycle cost competition, delivery competition, and reconciles statutory and regulatory differences in dealing with the concept of competition.

There is, of course, no such source or treatment of the concept. Often, the best that can be found is a definition of "price competition at the point of first production run." As anyone who knows acquisition for major systems can conclude without further research, this is the least likely point in the entire acquisition process to achieve meaningful competition.

## Bibliography

Since the acquisition process doesn't have a current bibliography constituting the body of knowledge for contract or acquisition process management, there is a very serious question to address.

## Need

The above observations suggest that all critical research tools necessary to conduct useful acquisition research do not exist and, to the extent they do, are of marginal research value.

The highest priority in acquisition research today should be the creation of the indispensable tools of acquisition research. As matters now stand, we have not created the body of knowledge necessary for wise conduct of acquisition and, certainly, not for the adequate conduct of acquisition research.

## II.

"Unless the results are known in advance, funding sources will reject the research proposal"

No federal-level entity has ever had the time, resources, staff and, most importantly, an organizing philosophy to promote the conduct of acquisition research.

We often are told about the first three (time, resources, staff), that's the cop-out of the Office of Federal Procurement Policy and the Federal Acquisition Institute which should be the clearinghouse function for acquisition research in the Executive Branch.

There is a better reason than budget or staff: It is that the need is not understood. There is no organizing philosophy to guide a careful examination of what is needed and how it might be achieved. For this, there is no excuse. It ought to be an essential capability for OFPP to look at the acquisition management community and identify related research needs.

OFPP has no budget for and no perceived interest in the conduct of acquisition research, yet research is an integral part of the statutory creation of OFPP.

The FAI has totally aborted on its original charter to be a clearinghouse for acquisition research. What is usually represented to be DOD research activities by the Services is most often designed as short-range coping devices to "clean out the in-boxes" of the material commands whose budgets support the research functions.

There is very little thoughtful, reflective, long-range research being conducted by existing DOD agencies. What is done is not part of a well-designed "systems approach" to research objectives which, in turn, is oriented to achieve problem avoidance in acquisition.

There must be an Executive Branch organizational focus for the conduct of research. If neither OFPP nor FAI will function in a clearinghouse role, then it should be undertaken by DOD in terms of its own needs.

The natural focus within DOD for such an initiative is the Deputy Assistant Secretary of Defense for Procurement. The irony is that this office has been negligent to a fault in supporting acquisition research because this office correctly has observed that the products of research, in general, over the years had become too arcane to be useful and further concluded that this observation discharged any further responsibilities on their part for the subject of acquisition research.

It was the absence of standards for the conduct of research and the absence of the proper tools of research that produced the aborts. It certainly wasn't lack of need for research or inability to perform.

DOD's observations were correct and superficial at the same time. The Office of the Assistant Secretary of Defense for Production and Logistics stands as an impediment to the conduct of acquisition research on a professional basis within DOD. Again, the irony. This office would be the greatest beneficiary of acquisition research products correctly conceived and addressed.

It is time for DOD to take a leadership role for the conduct of acquisition research on a basis which can make substantive contributions to contract management.

III.

"There is never enough time and money to do it right, but there is always time and money to do it over."

Of all the potential applications of acquisition research, the most pressing need is to address major systems acquisitions. Yet, research activities have failed to discipline research premises when addressing this key acquisition area.

Virtually all major system acquisition research efforts have been centered on problem coping. These have been research efforts to minimize the immediate concerns of cost growth, schedule slippage and, especially, performance shortfall. Rarely does such research address concerns with problem avoidance. The early business management considerations are separated in time by years, often many years, from the initiation of a production contract. This separation has been an excuse for the contract management community to distinguish a "proper time" to address "procurement" research matters. In the case of major systems, this proper time, while familiar to the traditional contracts community, is much too late to screen-out the adverse characteristics which most affect systems acquisitions.

As an example, take all the research activities that can be found on the subject of major system acquisition. Display the elements of research work statements on a time line of the acquisition process. What is invariably found is a great cluster of activities which deal with events in the time span from about a year before award of a production contract to the greatest concentration of efforts, focused on events after award.

Anyone with a passing knowledge of systems acquisition knows the problems are built into the process far in advance of this typical acquisition research time span.

The single, best example of missing the acquisition research target in this area is the requirements determination process. There are, of course, many other missed targets, difficult to see without an acquisition process model.

CONCLUSION/SUMMARY

The best, easily available analogy for meeting the needs at the several levels discussed above, is the Syntopican Index done for the Great Books. This index has the conceptual narrative of basic ideas - and it covers interrelationships and interdependencies. The index has hierarchies of subjects which correspond to the indexing needed for the acquisition process.

Finally, with key orientation and definitions in place, one may pursue the individual "research of ideas" with a certainty of the context to which one must return and account for research results if they are to be of any value.

# ACQUISITION STREAMLINING OPPORTUNITIES IN PRODUCTION

Mr. Darold L. Griffin, U.S. Army Materiel Command

## ABSTRACT

Acquisition Streamlining in Production can have a great impact on the the Army budget. However, it requires innovative techniques to maximize the amount of materiel being provided to the Soldier while maintaining performance and quality. The Deputy Chief of Staff for Production, U.S. Army Materiel Command has the responsibility for policy and staff management of the production phase and is developing the necessary policy and demonstration programs to insure success in production during a period of declining resources.

This paper describes the current environment in both Government and Industry and summarizes the overall Army approach to cost effective production and support to the U.S. Industrial Base. It also outlines the major initiatives that are under way and the documents which assist the Acquisition Community in implementing the policy in specific programs.

## INTRODUCTION

Acquisition improvement is and has been a major objective of the Department of Defense. The search for procedures and policies which will enable us to squeeze more and more capability, more and more quality and more and more quantity from available Government resources requires continuing effort and innovation to extract the maximum benefit from evolving law, technology and management practice. Acquisition Streamlining is the latest emphasis on that objective. By definition in DOD Directive 5000.43, Acquisition Streamlining is "any action that results in more efficient and effective use of resources to develop, produce and deploy quality defense systems and products. This includes ensuring that only cost-effective requirements are included, at the most appropriate time, in system and equipment solicitations and contracts."

With the dramatic reductions in the DOD budget that are currently anticipated, Acquisition Streamlining takes on a new sense of urgency. However, the overall philosophy remains the same: increased quality and productivity with decreased total cost of ownership. The first priority task in the mission of the U.S. Army Materiel Command (AMC) is to equip and sustain the soldiers in the field. Related missions include the establishment of surge and mobilization capabilities for production of materiel through a strong U.S. Industrial Base. Thus budget reductions can drastically impact the effective execution of that mission unless maximum innovation and efficiency are applied to the acquisition process to mitigate the effects of the loss of resources.

A review of the Army budget in rough figures clearly shows that the largest amount of resources is in the procurement appropriation and the key cost element in that appropriation is the production of materiel. Therefore, streamlining can have potentially the greatest effect when applied to materiel planning and execution. As the Deputy Chief of Staff for Production for AMC, I have spent the past four years developing and implementing policy and program initiatives to control costs and improve quality in production. Thus this paper will discuss the process of acquisition streamlining from the production prospective.

## ACQUISITION STRATEGY

The principal elements of Acquisition Streamlining are User Requirements, Acquisition Strategy, and Business Practices. While all are important to life cycle cost reduction, Acquisition Strategy and Business Practices are key elements with the greatest impact on the production.

The Acquisition Strategy is the principal road map to successful acquisition of materiel for the

Army. It provides direction for the large number of organizations that are involved in the development, production and deployment of defense systems within the Government, private industry and academia. When properly prepared and adhered to, the Acquisition Strategy minimizes waste and maximizes the effectiveness of the acquisition process. The following paragraphs highlight the most important factors of the Acquisition Strategy relative to the Production Phase.

The first is early commitment to production as the ultimate goal of acquisition. Early planning and acquisition activity must set the stage for smooth transition from development to production. By designing producibility into the hardware from the very start, production delays and cost growths can be minimized or avoided entirely. The relative cost of design changes increases dramatically as resources become committed to previous versions of the design.

The Acquisition Strategy must establish that early commitment to production by making producibility of design an integral part of the development scope of work rather than an afterthought or separate activity. Producibility is then part of the overall performance description of the design and the Army establishes its firm commitment to success in production. This integrated approach to engineering is facilitated by the use of multidisciplined design teams by both the Army and the Contractor. The term concurrent engineering is used by the DOD to describe the philosophy of addressing performance, production and all "downstream" considerations concurrently in the design process. This concept is enhanced by techniques such as conducting total design reviews with all team members rather than using multiple splinter groups which discuss only a limited aspect of the design in separate "ility" sessions such as Producibility, Reliability, Maintainability, and Supportability. Advanced technology is available to further enhance the process with the establishment of common computerized data bases and communications capabilities for members of the design team to insure continuous interaction among the various engineering disciplines during design evolution.

The second factor is the incentives provided to the development contractor to apply initiative and innovation to his producibility effort by tying the development contract to initial production and including a proof of production demonstration as part of the Acquisition Strategy. This gives the contractor the responsibility for his design producibility effort and the reward of production profits for success. It also provides both the Government and the Contractors with a target for continuous comparison of design with manufacturing capability. Of course there is no incentive at all, if the request for proposal (RFP) and the source selection criteria are not prepared in such a way as to emphasize production as the ultimate goal of the acquisition. Quality, producibility of design and production capability have a great affect on the soldiers' ultimate products. Weighting factors must be established to insure that bidders commit themselves to production not just development and the Source Selection Authority makes a decision with the quality delivery of end product as primary objective. The RFP must emphasize affordable products not just effective prototypes.

The cost and schedule risks of production are proportional to the level of design maturity that exists at the start of production. These risks can be reduced if the Acquisition Strategy requires that both the product and the production processes are proven out early in the life cycle. One way to accomplish this is to require the use of hard tooling for the manufacture of the hardware used in Development Test II and Operational Test II (DT/OT II). The initial prove out production line can be unbalanced in a classical industrial engineering sense in that the full complement of equipment may not be present in the numbers required to optimize the production rate. However, it must be comprehensive in that all operations are represented. The establishment of this prove out line also serves as the basis for the identification of the critical processes, their control parameters and perhaps even a rough range of acceptable values which then become the basis for statistical process control for the full production line. By planning for such prove out in the Acquisition Strategy, the Acquisition Team can focus their efforts on establishing a mature design and timing the expenditure of resources to meet production objectives.

Further commitment to a mature design prior to production is insured by conducting a first article test and configuration audit during full scale development. This approach validates the Technical Data Package and certifies the production line established under prove out and being completed in preparation for full production. It also provides an opportunity of further refinement and validation of process control techniques.

The final factor in the Acquisition Strategy to impact the production phase is the plan for the transfer of production technology from the development contractor to another producer in the event that multiple sources are required. The net effect is to drive down the cost of the final product through competition, expand if needed the industrial base to provide the requisite peacetime quantity of product, and establish a base for mobilization requirements. However, the requirement must be established early and synchronized with product delivery rates so that contractor to contractor agreements and the people to people interfaces can be negotiated efficiently. This approach is essential to the effective transfer of production expertise which cannot be left solely to the Technical Data Package (TDP). (The typical Army TDP is generated to be used for acceptance inspection of product rather than "how to" instructions for production. Hence, the cooperative efforts of both contractors are required to develop a successful second producer.) The contractor to contractor technology transfer can also be enhanced by the use of electronic transfer of data utilizing the Computer-aided Acquisition and Logistics Support (CALS) data exchange standards that are currently being developed. However, program instability or deviation from the approved Acquisition Strategy can result in cost increase or wasted resources.

## PROGRAM STABILITY

Program stability plays a critical part in minimizing total cost in production. Once established, the Army must stick with a comprehensive Acquisition Strategy to eliminate wasted efforts and restarts. The initial quantities planned for procurement must be adequate to support the necessary capital investment required for production and are an important factor in deciding whether or not the end item is affordable. Changes in quantity can affect overall affordability decisions. Where multiple sources are required, business shares must be allocated to insure amortization of each source's investment over a reasonable time period.

On a case by case basis, protection of capital investment can be guaranteed when high risk is present through contractual provisions. However, even though indemnification clauses protect private investment, they consume resources when quantities are cut and the Contractor files a claim. More important to successful acquisition are concepts which permit variation of quantity with lower cost penalties, for example encouraging the use of general purpose/flexible equipment for production allows the contractor the opportunity to reallocate his capital investment to commercial or other defense products in the event of program reductions or early curtailment. These options are facilitated by active producibility engineering during initial production design. The Acquisition Strategy can also contain alternatives which support surge and mobilization requirements by maintaining a low level of production through sole source contracts or preserving a production capability by reimbursing the Contractor to layaway equipment for future peacetime production or surge requirements.

## TOTAL QUALITY

The Acquisition Streamlining aspects of production are consistent with the total quality concept in that they promote a close relationship with our customers and continuous improvement of the Acquisition Process. The tools which we have developed enhance these opportunities. Our customer is the soldier. A close relationship results in minimized, quantifiable and achievable system requirements. This relationship must be cultivated continuously through the development phase and into production by active User participation. The adherence to a concurrent engineering philosophy in development insures that the design is robust and the end item is easier to produce, operate and support in the field. Active people involvement and manufacturing process discipline in iterative design/evaluation cycles improve overall quality and lower the cost of ownership. Dedication to process control forces scrap and rework to become unacceptable costs on the factory floor.

## TOOLS FOR QUALITY

There are established tools for improving quality in production which will not be discussed in detail. Producibility Engineering has already been mentioned within the context of a multi-disciplined design team and the need for design maturity prior to the start of production. Contractor reliability growth and warranties have certainly played an important part in getting commitment to excellence through incentives and penalties. Preliminary results have established the cost savings of environmental stress screening as a way to eliminate weak or marginal components prior to being inserted into electronics equipment and thus improving performance in the field. Other recently established tools include: Process Control, Contractor Performance Certification Program, Contractor Productivity Improvement, Acquisition Improvement Reviews and Technical Data Strategies.

Statistical Process Control (SPC) is not new and has been used at Rock Island Arsenal since 1983. It is currently being used at all Army depots and arsenals with over 1500 people trained in the SPC methodology. The investment of that time and money has been rewarded with a 75% reduction in non-conforming material at Rock Island Arsenal and a savings of $1.1 million in scrap, rework and waivers. At Watervliet Arsenal, over $1.3 million has been saved in repair, rework and tooling cost by the use of SPC with an estimated $16 million saved as a result of the avoidance of scrap costs. By first establishing the critical ranges and then monitoring the values of process parameters, SPC emphasizes prevention of defective product rather than detection of defects through inspection. Monitoring of the process can be done manually or through automated sensors. Likewise the adjustments to the manufacturing process can be done manually or through adaptive control.

The concept of SPC has been expanded to include all aspects of process control to reduce or eliminate the need for end item inspection. A science based understanding of each aspect of the process is required to identify the critical parameters and the acceptable range of values. Such techniques as the Taguchi Method have been shown to be cost effective in identifying critical parameters and the acceptable ranges through a new approach to the design of experiments. Once established, however, proof of quality from a production line can be documented by the associated process control data rather than inspection reports.

The Contractor Performance Certification Program (CP)2 recognizes contractors' commitment to continuous quality improvement and rewards them with reduced requirements for inspection and other quality control procedures. Both the Government and the Contractor benefit from the certification process through reduction in manpower for non value added activity. The program requires the contractor to establish quality performance requirements and plans, and the Government then certifies the plans and approves quantifiable milestones for quality measurement and improvement. A well established process control program is essential to certification. The current limiting factor on this program is that the investments in the certification process can only be recouped on long term, high dollar value contracts and therefore it is restricted to $100 million RDTE and $500 million production programs.

AMC utilizes Acquisition Improvement Reviews (AIR) through my office to conduct contractor and Army management assessments over a broad range of programs. Some have been done on an Industry-wide basis while others have been done within a single company but across a number of product lines. During the review a Government/Contractor team evaluates current design, test, production and management practice with the goal of improving cost, schedule, quality and technical performance. The Army Project Manager, the Head of the Contracting Agency and the Contract Administrative Service are all involved and are briefed on the results. The report and recommended action plan are prepared as the review is conducted so that feedback to the management team is provided quickly and a summary is briefed prior to the AIR team's departure. The results not only provide a recommended course of corrective action but also can be used as the basis for establishing Manufacturing Technology or Industrial Modernization Incentives Programs. Because the scope of an AIR is broader than a single system, there is greater opportunity to foster the continuous improvement of productivity and to identify any artificial barriers imposed by the Government which drive up costs by limiting the use of best commercial practices by Industry. Thus the AIR establishes a two way dialogue between Industry and Government to enhance the Acquisition Process.

An initiative that is currently being developed under a test project is Contractor Productivity Improvement (CPI). This initiative attacks the problem of high cost due to inefficient processes, procedures and manufacturing equipment and provides a comprehensive solution for reducing costs while limiting the risk of capital investment. The Government and Contractor share the costs of productivity improvement. The Government recovers its investment through lower prices for the product whereas the Contractor benefits by increased competitiveness for future contracts. The Manufacturing Technology Program can also produce improvement in the processes and equipment in production but lacks the breadth and resources to solve the broad problem within a manufacturing plant. The actual procedure being used is a variation on the Industrial Modernization Incentives Program (IMIP). The basic methodology follows below.

CPI is based upon a separately negotiated contract for productivity improvements which span several programs within the manufacturing plant. The Army's investment is limited to approximately 2% of the annual sales from the plant while the contractor commits his resources to a 25% share of the project costs. The Contractor proposes the projects based upon his own analysis. Projects are selected for which the period for 100% return on investment is four years or less. After the initial test project, all contractors will be eligible to participate with the involvement of the supplier base encouraged where feasible. Investment will be financed through the procurement appropriation and the contractor will keep title to the equipment and data after the Government's investment has been recovered.

Acquisition Streamlining is directed at the software and paperwork aspects of the production phase of the life cycle not just the production of hardware. Two specific efforts attack the cost of paper products.

First, the "Could Cost" program invites Industry to challenge all requirements for analyses, reports and manuals that have not been filtered out through the data review board process established within all AMC subordinate commands. These are serious opportunities to propose major program changes to reduce the total cost of ownership of defense systems. Under "Could Cost" all areas of the program are subject to discussion for alternate approaches or elimination. The second is a change to the traditional mind-set by defining program requirements in terms of performance specifications rather then detailed "How To" specifications. Major Army programs such as the Mobile Subscriber Equipment (MSE), Anti-Armor Weapon System - Medium (AAWS-M) and Light Helicopter-Experimental (LHX) have been based upon such a philosophy.

Specifications and standards may become outdated and counter-productive and are periodically presented for Industry review and criticism to insure that evolving best practices are not being excluded by outdated requirements. Of particular significance to such policy is a current joint effort between the Army and the Navy to develop a science-based standard for soldering technology. Value Engineering studies and methods can also be used to reduce the cost and scope of specifications and standards. Finally the mountain of paperwork that is frequently associated with a Government solicitation is being reduced by making the contract binding only on Category 1 specifications, that is only those that are directly referenced in the solicitation and not those that are subsequently referenced. All of these ideas stress the philosophy of tailoring requirements to match the Acquisition Strategy and allowing review of the validity by a competitive industrial base.

## TECHNICAL DATA ACQUISITION

The streamlining of Technical Data Package (TDP) acquisition is also required to reduce overall program costs. The Acquisition Strategy is the guide to developing a complimentary strategy for the level of detail required in the Technical Data Package to be delivered by the development contractor. Quantity of production, length of field service expected, maintenance concepts, spare parts strategies, and cost impact the decision for the level of detail required in the TDP. Tailoring of the Technical Data Package requirements can ultimately save money by avoiding the expense of drawings and specifications which may not be needed for competitive procurements or by reducing unit costs via competition during follow-on production. In either case, changes to the Acquisition Strategy after contract award can result in large expense for the Army.

Automation of technical data can lower life cycle costs by reducing the manpower requirements of the Government and Industry in preparing, accepting, storing and distributing technical data.

Automation can also improve the responsiveness of Industry reaction to needs of hardware production. Automated repositories are being completed at the AMC Major Subordinate Commands and selected technical data is being loaded into these systems to provide rapid and accurate assembly of Technical Data Packages for solicitation. The completion of standards for technical data representation and transfer through the CALS program will further reduce the expense of documenting and transferring technical data.

## POLICY AND GUIDANCE

In addition to the concepts and programs described above, the Army Materiel Command has published several tools recently to formalize these efforts and promulgate the methodologies to all acquisition personnel. MIL-HDBK-792(AR), "The Prove Out of Production Facilities," (24 March 1989) serves as an aid to those activities establishing or modernizing production facilities and presents a statistically based methodology as a way of assessing the ultimate capability of the planned facility. Another document, "Program Management Risk Reduction Road Maps" is currently in publication and will provide the Army perspective on managing production risks during the life cycle. It is the bridge between DOD Directive 4245.7M, "Transition from Development to Production" and Army Streamlined Acquisition.

AMC Pamphlet 70-21 provides guidance for the preparation of Production Readiness Master Plans (PRMP). The PRMP is the basic documentation of design producibility requirements, the identification and resolution of production barriers, production planning and management processes. It is updated as issues are resolved and decision points within the life cycle are met. In addition a companion regulation to AR 70-1, "Systems Acquisition Policy and Procedures", is being prepared to integrate all Army production policies and procedures and serve as a complete reference for other documents which contain more detailed information. It will be finalized in early 1990.

The goal of the Deputy Chief of Staff for Production is "Success in production." Competitiveness in manufacturing has become a National issue as other countries have taken away long standing American product markets with aggressive cost reduction and total commitment to quality. The Army has not been idle in developing both contractual language and program management guidance to incorporate action and planning strategies that support a competitive U.S. Industrial Base with low cost and high quality products. Continued cooperation is required with both Industry and Academia as partners in evolving these initial efforts into fully accepted ways of doing business.

## TRAINING

Training is still a critical element in this effort. University curricula include manufacturing engineering as well as industrial engineering and aggressive research programs in manufacturing science and technology. The Army recognizes Production Engineering training and career growth in both its formal School of Engineering and Logistics at Red River Army Depot and its career development plan under the Engineers and Scientists (non-construction) Career Program. Skill in producibility engineering requires extensive knowledge of manufacturing processes and materials as well as knowledge of potential barriers to production which can be created in design. Knowledge-based systems can also assist design engineers in process and materials selection and the conduct of producibility analyses and production readiness reviews. These and other techniques described earlier will require extensive training of technical, procurement and management professionals to insure an appropriate risk/reward ratio for both the Contractor and the Government.

## SUMMARY

Regardless of how effective these Production Acquisition Streamlining techniques might be on an individual basis, the greatest advantage is derived from an integrated combination of techniques which are selected based upon the Soldier's needs, maturity of technology, and the capability of the U.S. Industrial Base. Continued research, analysis and implementation of sound, business-based acquisition methods can support an appropriate level of defense readiness in an environment of decreasing Government resources. The Army has positioned itself to do so.

# EARLY INTEGRATION OF INDUSTRIAL PREPAREDNESS PLANNING INTO THE ACQUISITION PROCESS

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## ABSTRACT

The objective of this paper is to emphasize the importance of early integration of industrial preparedness considerations into the acquisition process. The requirement to do so exists at the highest levels; the procedures to do so may not be as explicit. However, the omission of this element creates inestimable remedial efforts down the road (during the production phase) and significantly impacts the readiness posture of the United States. These views are those of the author and do not necessarily represent the views of the Headquarters, US Army Armament, Munitions & Chemical Command.

## INTRODUCTION

According to numerous newspaper and magazine articles on our defense posture, and as stated in a publication by the Defense Systems Management College (1), "Every DoD exercise and mobilization study conducted in the last ten years has documented the fact that the United States is not prepared to fight any war of consequence. Senior military officials have contended--and recent sustainability studies support the view--that U.S. forces could sustain only a few weeks of a major conflict in Europe."

Although numerous Department of Defense (DoD) regulations require consideration of an acquisition's impact upon the industrial base and that system acquisition and production readiness reviews address the industrial base capability to surge and mobilize, it doesn't appear to be happening, at least not as early as it is expected to be and, certainly, not as early as it should. DoD Directive 5000.1 (2) provides policies and procedures for managing major and non-major defense acquisition programs. Specifically, this directive makes the following points:

- A strong U.S. industrial base is essential for a strong defense. Accordingly, the near-term and long-term implications and ramifications of proposed acquisition programs on the U.S. defense base shall be explicitly considered during the decision making process.

- Logistic supportability requirements, in the form of readiness goals and related design requirements and activities, shall be established early in the acquisition process and be considered in the formulation of the acquisition strategy. They shall receive emphasis comparable to that accorded to cost, schedule, and performance objectives and requirements.

- To enhance program stability, DoD Components will plan for economical rates of production, surge and mobilization requirements, and, where appropriate, multi-year procurement.

While it might have been preferable for this directive to also read "Provisions for achieving readiness in each phase of the acquisition process shall be described in the acquisition strategy," as it does for competition, clearly the emphasis to consider industrial preparedness and to do so "early" exists.

In a response to Congressional inquiries on the policies for managing the Army's ammunition production base (3), the Assistant Secretary of Defense for Production and Logistics described the mobilization production base:

> "The mobilization production base is that portion of the United States and Canadian industrial base needed to support projected wartime needs. To achieve this goal, mobilization base considerations are

incorporated early in the development cycle. Furthermore, critical items and critical components are restricted to the United States and Canada as a minimum, and can be further restricted to mobilization base producers or to critical producers, if required, for industrial preparedness purposes. End items and components are analyzed and item planning accomplished to balance the mobilization base. The production planning schedule (PPS) contract will be used as a vehicle to identify and retain production base capacity for mobilization planned items.'

## ISSUES

The requirement to incorporate industrial preparedness provisions during the development cycle is not early enough. Recent streamlining initiatives affecting the review and acquisition strategy processes have, no doubt, resulted in savings in both time and money. But, should any critical element (such as industrial preparedness planning) be omitted from consideration at program initiation, the streamlined efforts make it almost impossible to consider the element until the full-scale development phase, at which time the emphasis is on the plan to transition from development to production, and the strategy is pretty much locked in.

At this point in time, it is likely that no, or little, consideration has been given to the impact on the United States/Canadian industrial base (not to mention the mobilization production base) should the development and subsequent production contracts be placed with foreign producers. Further, it is possible that no analyses of critical components has been performed. A critical component may turn out to be a component for which we are dependent upon a foreign source, and as such may not be available in the event of a national emergency, thereby impacting the readiness of the entire end item.

These are not new concerns. Presently, though, they do not generally become concerns until the item is well into production. For example, once an item is in production and upon receipt of the technical data package, the responsibility for the identification of critical components falls on the industrial specialist. One vehicle which may be used to gather such data is the Industrial Preparedness Program Production Capacity Survey, DD Form 1519 TEST (4). Relevant industrial preparedness data is provided to the Government by the contractor on the DD Form 1519, verified by the ASPPO, and evaluated by the industrial specialist. The ASPPO, or the Armed Services Production Planning Officer, is the Government designee responsible for performing industrial preparedness planning in plants under his or her cognizance.

Very simplistically, the industrial specialist, then, evaluates the situation in relationship to formal mobilization requirements, identifies industrial preparedness measures, and makes recommendations as to the appropriate method of procurement. In the case of foreign dependencies, either for the end item or a critical component, these measures include developing a domestic source, stockpiling, substitution, reverse engineering, etc., all of which are costly and preventable in many cases. Or, the industrial preparedness measure needed may only require an evaluation and simple determination that, in fact, we are not foreign dependent (only foreign sourced) and that adequate capability does exist in the United States/Canadian industrial base. A further determination that foreign sourcing is not significantly impacting the domestic source(s) to the detriment of the industrial base (or to the detriment of the mobilization production base) and that the domestic source(s) will be available to satisfy the mobilization requirement in the event of a national emergency would also be needed. Presently, industrial specialists and ASPPOs are working together to obtain industrial preparedness data and to further obtain a formal commitment from members of the industrial base to provide and maintain the capacity needed to satisfy mobilization requirements.

The point is that many of these efforts need not be undertaken if industrial preparedness were considered earlier. This issue requires emphasis at no lower than the Program Manager level. Certainly no one has better insight into a particular program than its' Program Manager. For example, generally the Program Manager is keenly aware of the prime's major subcontractors, but less aware of the subcontractors and vendors for lower level components. The Program Manager's Handbook (1) addresses this issue and offers a method for analyses. In this example, the analysis must begin before the hierarchy is even established. Specifically, the handbook advocates that during concept design the Program Manager should identify any components which will require exotic materials or high risk technologies. Then, as the prime contractor begins to establish the vendor base and develop the make/buy plan, the Program Manager should develop, in the form of a work breakdown structure, the sources of components. With this knowledge, the Program Manager will become increasingly aware of the breadth of the program's base and will likely be able to identify potential production bottlenecks. Whichever method the Program Manager chooses to evaluate the industrial base and to consider issues such as foreign sourcing and/or dependency, it is clear that the Program Manager's decisions will indirectly impact areas other than readiness; areas such as competition, the general industrial base, contracting, and cost will all be affected by these decisions.

Resources are a problem for everyone, including the Program Manager. Both the ASPPO and the industrial specialist are available to assist the Program Manager in the analysis of the mobilization production base or the United States/Canadian industrial base, and the Program Manager is strongly encouraged to take advantage of these services. DoD Manual 4005.3 (5) directs that maximum use shall be made of the ASPPO's expertise and current knowledge of the prime contractor's purchasing and production leadtimes for manufacturing, materials, components and subassemblies. Very often, these sources have more indepth knowledge of a particular contractor or item than is available on a Program Manager's staff.

Only recently has guidance (6) been published at the DoD level which identifies acquisition planning requirements for industrial preparedness planning. Although more determinate than previously issued guidance, procedures must yet be established. Specifically, this guidance reads:

> "Procedures shall be established to ensure that for written acquisition plans meeting the criteria and thresholds of..., the program manager's industrial preparedness strategy and plan to accelerate, surge, or mobilize production has been considered in the acquisition strategy and has been documented either by text or by reference in the acquisition plan. This strategy should clearly include secondary items, spare parts, etc., necessary to support the system."

This new guidance, effective 1 May 1989, provides not only for written documentation of industrial preparedness strategy, but also requires written rationale if an industrial preparedness (IP) strategy is not applicable, which at least necessitates consideration of industrial preparedness planning.

> "Provide the program's IP strategy that assesses the capability of the US Industrial Base to achieve identified surge and mobilization goals. If no IP strategy has been developed, provide supporting rationale for this position.
>
> "If in the IP strategy, the development of a detailed IP plan was determined to be applicable, include the plan by text or by reference. If the development of the IP plan was determined to be not applicable, summarize the details of the analysis forming the basis of this decision.
>
> "If the program involves both peacetime and wartime hardware configurations which are supported by logistic support plans, identify the impact of these plans on the IP plan."

## CONCLUSIONS

- A strong U.S. industrial base is essential for a strong defense.
- Industrial base issues are not normally addressed during the early phases of the acquisition process.
- When industrial base issues are not considered early-on in the acquisition process, the incorporation of industrial preparedness provisions at a later point is costly and time consuming.
- Industrial base decisions and the impact of these decisions on readiness, competition, foreign dependency, and contracting must be incorporated within the program baseline and consistently addressed at each review thereafter.
- The Program Manager has the best visibility into a program and has access to expertise on industrial base issues in the form of the ASPPO and the industrial specialist.
- The Program Manager is in the best position to identify and implement measures which will enhance the industrial base and is able to do so early in the acquisition process when such efforts are most effective and efficient.
- Early integration of industrial preparedness considerations will ensure that the system or item is mission capable and can be produced in quantities to satisfy mobilization requirements, thereby enhancing the readiness posture of the U.S. industrial base.

## SUMMARY

The industrial preparedness issues presented in this paper are but a few that should be considered when addressing areas such as the industrial base, and its impact on competition, cooperative opportunities, technology, constraints, acquisition strategy, and, most importantly, readiness. Keep in mind that DoDD 5000.1 (2) calls for logistic supportability requirements, in the form of readiness goals and related design requirements, to be considered early and to receive emphasis comparable to cost, schedule, and performance. Therefore, it is imperative this element be addressed within the program baseline as a factor critical to the success of the program. More recent guidance (6) specifically requires an industrial preparedness strategy be included within the formal written acquisition plan. This early consideration of industrial preparedness will serve to eliminate potential efforts to "undo" problems which could have been avoided and, as such, will serve to enhance the defense posture of the United States.

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MODEL ACQUISITION METHODOLOGY FOR THE ACQUISITION OF
SOFTWARE LIFE CYCLE SUPPORT SERVICES

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## ABSTRACT

For years, organizations have had difficulties in contracting for software life cycle support services. The acquisition process is lengthy and resulting contracts are not often responsive to the dynamic requirements of the organizations seeking support. Approximately four years ago, the United States Air Force Military Airlift Command (MAC) approached the General Services Administration (GSA) Federal Software Management Support Center (FSMC) and MITRE with a request to investigate and if viable develop a new acquisition strategy with supporting methodology for acquiring software support services. The objectives of this effort were to:

- Maximize responsiveness to software service support needs.
- Satisfy the workload demands for the full range of life cycle software support activities. (Requirements through maintenance.)
- Provide a wide range of available technical skills
- Maximize the use of in-house resources
- Minimize the workload associated with the acquisition process
- Reduce the time normally associated with acquisition of software services.

While the original work was done to satisfy the requirements of MAC, the strategy and model documentation has been intentionally expanded so that it may be adapted by any government organization to acquire software services for entire functional areas, individual systems, or groups of systems depending on the needs of the organization.

This acquisition strategy has been successfully used by a number of government agencies and in December 1988 was officially released by GSA FSMC as a guideline/recommended approach for the acquisition of software life cycle services (1).

## INTRODUCTION

Over the last ten years, such terms as "out of scope" and "non-responsive" have become synonymous with software service related acquisitions. The acquisition process is lengthly, organizations frequently can not clearly define their requirements and therefore resulting contracts do not provide a level of responsiveness sufficient to address the dynamic nature of the requirements and or environments of the organizations seeking assistance. In 1985, MITRE was approached by representatives from the General Services Administration Federal Software Management Support Center and the United States Air Force Military Airlift Command with a request to investigate and if feasible develop a new acquisition strategy to address just such issues. The initial thrust of the effort was to focus on assisting MAC in the acquisition of software maintenance services.

Over a thirteen month period, MITRE not only determined the viability of such a new acquisition approach but successfully implemented for MAC a prototype acquisition for software maintenance. Based on this initial success, all parties agreed to expand the approach to address the acquisition of the full range of software services/activities normally associated with systems.

The result of this two and a half year effort has been the development and documentation of a Model Acquisition Methodology for the Acquisition of Software Support Services (2). This model not only includes a description of the strategy to be employed during the acquisition process but also contains an explanation of the various acquisition activities from pre-solicitation planning through contract administration. To facilitate implementation, standardized models for the Request for Proposal, Source Selection Plan and Evaluation Criteria are provided and can be easily modified by an organization to meet their specific needs or objectives.

The following text of the paper provides a brief description of the development of the Acquisition Strategy, highlighting specific features of the Strategy and discusses a number of lessons learned regarding the implementation of the strategy.

Development of the Acquisition Strategy

The first step in the development of the Acquisition Strategy was to establish a baseline set of operational criteria on which each alternative could be evaluated. This set of criteria had to be selected in such a way as to take into account the basic problem areas, as mentioned earlier, associated with contracting as well as address the typical existing environments in which government organizations are asked to function. Based on this information, the following five criteria were selected:

- Responsiveness - The capability of acquiring software maintenance services in the shortest possible time.
- Flexibility - The capability of satisfying the widest range of requirements within a single contract.
- Adaptability - The capability of tailoring the basic contract to cover unanticipated changes in requirements with minimal effort.
- Simplicity - The attribute of the contract that, along with model task orders, will reduce the workload of senior contracting officers.
- Control - The attribute of the contract that defines contractor responsibilities and includes effective mechanisms for assuring contractor performance in the areas of service quality, delivery of products, and meeting of schedules with provisions for appropriate incentives and penalties.

These criteria coincide/augment somewhat criteria published in the July 1984 "Acquisition Strategy Guide" (3) published by the Defense Systems Management College.

Using these criteria, MITRE then conducted an exhaustive review of contracting approaches in the Federal Acquisitions Regulation (FAR) (4) to include:

- Basic Agreement: A written instrument of understanding between an agency and a contractor. It is not a contract, but contains contract clauses, which the contractor agrees to, and can be included by reference in future contracts.
- Labor Hour Contract: Provides for acquiring services on the basis of fixed hourly rates.
- Requirements Contract: Provides for filling all actual purchase requirements of designated services during a specified period, with deliveries to be scheduled by placing orders with the contractor.
- Multiple Award: The appropriateness of selecting one versus several contractors.
- Fixed Price Contract: Provides for a firm price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract.
- Cost - Reimbursement Contract: Provides for payment of allowable incurred costs to the extent prescribed in the contract.

Based on MITRE's analysis of these approaches, it soon became apparent that no single approach could satisfy sufficiently the criteria. MITRE then investigated the feasibility of combining approaches thus taking advantage of the strengths of each. Based on this effort, the strategy which ultimately evolved centers around the integration of indefinite-quantity and requirements-type contracts.

Acquisition Strategy Description

The Indefinite-Quantity and Requirements-type contracts are described in Federal Acquisitions Regulation 16.504. Implementation of a combined strategy will put into place a basic contract which is used to define the overall organization, functional areas, system or group of systems to be supported, as well as to specify the broad range of services, deliverables and skill levels required. From this contract an organization can obtain a breadth of software services either from a single contractor or multiple contractors based on the organizations' requirements/preferences. Use of a multiple contractor approach encourages competition, provides greater depth from which organizations may draw support, reduces risk and provides the flexibility to cultivate specific contractor specialties. The mainstay of this strategy; however, centers around the individual task order. It is within the task order not the basic contract that the organization must specify the actual work to be performed by the contractor. Individual task orders can be either of a fixed price or cost-reimbursement variety. Fixed price task orders are preferred as they provide greater control to the government for enforcing delivery. Fixed price task orders can only be issued when an organization can clearly define the work required and the level of contractor performance is predictable. Cost-reimbursement type task orders can be effectively used only for work of a research or development type where the work and or level of effort required of the contractor can not be clearly defined.

The scope of an individual task order will vary depending on the nature of the work to be performed and the prevailing preferences of the organization.

### Acquisition Strategy Results

This approach to acquiring software services has as of this date been used successfully by three organizations on four separate acquisitions. The implementation of this strategy has resulted in:

- maximization of responsiveness to software service support needs
- satisfaction of the workload demands for the range of support services requested
- the availability of a wide range of technical skills
- minimization of the workload associated with the acquisition process
- reduction in the time normally associated with the acquisition of software services

Issues surrounding the strategy which organizations should be aware of and address include:

- the need to encourage/insist on the involvement/participation of all relevant organizational components from the out set of the acquisition effort
- the need to implement a strong contract administration capability within the organization both from a technical and financial point of view
- the need to ensure to the contractors a steady stream of task orders to ensure that experienced staff are not lost and to continue to cultivate specific contractor capabilities.
- the need during the Source Selection Process for pre-award offeror presentations and or Government visits to offeror facilities
- the need to establish a firm basis of understanding between the Government and the contractor in the methodologies and tasks which the contractor will be using in the preparation of time and effort estimation for task orders.

## CONCLUSIONS AND SUMMARY

An acquisition Strategy based on the indefinite quantity requirements concept and utilizing task orders for the execution of work appears to be an effective mechanism for addressing the classical problem encountered today in software service acquisition. By utilizing the model methodology and documentation, organizations have been able to:

- reduce the time normally associated with the acquisition of software services
- minimize the workload associated with the acquisition process freeing resources for redirection into other organizational priorities
- maximize responsiveness to software service support requirements
- satisfy the workload demands for the full range of life cycle software support activities
- obtain a wide range of available technical skills

The cost to utilize such a strategy is that it requires the organization to:

- adjust to a new method of acquisition
- requires implementation of a strong contract administrative capability
- and necessitates an active involvement of all parties earlier in the acquisition process.

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## PROCUREMENT LEADTIME: THE FORGOTTEN FACTOR

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### ABSTRACT

Procurement leadtime, the time required to order and receive material, is an important element in the development of material requirements in any inventory management system. While the length of procurement leadtime for purchases for direct customer use is uniformly recognized as an important element in the overall level of customer service provided, the critical significance of procurement leadtime for the routine procurement of material for inventory is typically not adequately appreciated or considered in basic Department of Defense (DoD) procurement and inventory management processes.

Indeed, many DoD logistics management strategies implemented in the past several years, from the implementation of provisions of the Competition in Contracting Act to increased minimum order quantity levels, have often largely disregarded the related impact of these initiatives on procurement leadtime. However, the length and variance in procurement leadtime directly impacts inventory investment, demand forecast accuracy, inventory turbulence, the risk of uneeded inventories, and system responsiveness. These negative impacts of longer procurement leadtimes are becoming increasingly clear as DoD inventories relative to demand continue to increase and inapplicable inventories (both in absolute and relative terms) continue to grow.

In comparison to recent trends in DoD inventory management, successful private sector firms have traditionally recognized the importance of leadtime management to profitability and long-term market success. In the early 1980's, as the level of overall market competition increased dramatically for most U.S. firms, many of these placed a much a greater emphasis on the supply channel aspects of the overall material flow and began to move to time-sensitive procurement and distribution systems under the so-called "just-in-time" concept. This extension, by the inherent nature of just-in-time strategies, mandated an ability to minimize and manage procurement leadtimes and necessitated fundamental changes in vendor relationships and procurement methods and strategies. Results in many firms adopting these time-sensitive techniques have been dramatic.

This paper examines procurement leadtimes and leadtime management in both the DoD and private sector environments. Drawing on data collected from numerous private sector firms, DoD vendors, and from DoD inventory managers, empirical differences in aggregate procurement leadtime profiles are developed and analyzed. Using a sample of several hundred **identical items** bought both by the DoD and private sector firms from the **same suppliers,** specific procurement leadtime differences are also developed and used to illustrate the impact of these key differences on inventory investment. Finally, the paper extends the discussion to a consideration of those major DoD procurement and inventory management policies and practices that are negatively impacting procurement leadtimes and recommends revisions to these DoD policies and procedures.

## INTRODUCTION

**Background.** In today's dynamic acquisition environment, the effectiveness of the interface between the requirements determination process and the procurement process is vital to the overall success of the Department of Defense (DoD) logistics system. As operating pressures grow and public interest and Congressional oversight increase, the ability of the DoD logistics system to meet material support needs while ensuring cost-effective management and providing visible integrity will require the development of innovative management strategies, and supporting policies, procedures, and information systems, geared to achieving the joint goals and objectives of both the procurement and inventory management functions.

Unfortunately, most of the recent policy initiatives in DoD acquisition have tended to focus almost exclusively on specific deficiencies and operating problems in the basic procurement process viewed in isolation. Many of these changes have been driven by the Competition in Contracting Act (CICA) implemented in 1985. In general, the thrust of these initiatives to improve the acquisition process has been on increasing the level of competitive awards, reducing the prices paid for goods and services, and enhancing system integrity. There is no question that many of these initiatives have proven beneficial to the DoD, and to the nation, given these specific objectives. At the same time, however, the negative impact of these acquisition initiatives on other elements of the DoD logistics system, and on total long-term cost to the taxpayer, has received much less attention.

Further, when viewed in the context of the significant revolution in logistics management strategy and thinking which has occurred in the private sector in the decade of the 1980's, these initiatives are, in large part, moving the DoD in a direction which is essentially opposite to that of most successful private sector logistics systems. Horizontal management philosophies, with joint goal-setting and performance measurement across functions, has become a standard in successful private sector logistics systems. Vertical management, with separate goal-setting and performance measurement within functions, is still the norm in the DoD. Today the results of this vertical management philosophy are becoming increasingly clear. As processing times increase, inventory managers often seek to compensate by increasing the investment in safety levels and to reduce workload by increasing order quantities for inventory replenishment. However, with increasing processing times, the risks of higher safety levels and larger order quantities are more substantial in that demand forecasting is typically less accurate. Accumulation of uneeded inventories is the inevitable result. Since FY 1983, DoD inapplicable inventories of secondary items have increased four-fold and in FY 1988 totalled almost $ 30 billion. Today, about one-third of all secondary item inventory on-hand is inapplicable to known requirements. Further, about one dollar in ten of material still on order is already inapplicable to known requirements. In short, the DoD logistics system has become sluggish, time-bound, and inflexible.

**Scope.** In this paper we examine one key element of the DoD procurement and inventory management system-procurement leadtime. The paper summarizes the results of a series of studies[1] conducted over the period 1984 through 1988. For our purposes, we define procurement leadtime as the time required to acquire materiel for inventory. It is typically measured from the point in time when the requirement is identified until the point in time when a significant portion of the materiel required is delivered to the DoD. Procurement leadtime has two separate components, each of which is generally measured and managed separately in standard DoD logistics systems. Administrative leadtime is the time from the identification of a material requirement until the award of a contract for the requirement. Production leadtime is the time from contract award for the requirement until the material is delivered to the DoD logistics system. Thus, in a very real sense, procurement leadtime is the major link between the inventory management system and the procurement system and procurement leadtime management is the joint-responsibility of both functions.

In our discussion of procurement leadtime here we deliberately limit the scope of the analysis in several ways. First, the paper deals exclusively DoD spares and repair parts, often called secondary items. These items include both consumables and recoverables ranging in price from less than a dollar to several hundred thousand dollars per unit and in complexity from general purpose, commercially-available items to highly sophisticated, unique electronics. Second, the procurement leadtime data analyzed are for procurement of material for inventories and not for direct customer support. The items included in the analysis are managed within the DoD logistics system by a single wholesale manager and specific Inventory Control Points (ICPs). Third, the operational environment represented in the study is the "steady-state" replenishment phase of the system or item life-cycle which follows system introduction. Thus we will be discussing procurement leadtimes for items which have already been initially sourced and introduced into the DoD inventory as a stocked item via the provisioning process.

**Leadtime Trends.** DoD procurement leadtimes for secondary items have increased since FY 1983. As seen in Table I below, the increase was particularly dramatic from 1985 until 1987. Two major factors are related to these specific period trends. First, market conditions for selected items increased production leadtimes not only for the DoD but also for many private sector firms. Second, substantial growth is clear in Administrative Leadtime and much of this increase can be related to the increased processing requirements of CICA-based initiatives.

**TABLE I**
**DoD Procurement Leadtime Trends**
(Dollar-Weighted Days)

| | 83 | 84 | 85 | 86 | 87 | 88 |
|---|---|---|---|---|---|---|
| Admin. Leadtime | 125 | 132 | 160 | 201 | 270 | 255 |
| Prod. Leadtime | 392 | 399 | 436 | 448 | 452 | 482 |
| Procure. Leadtime | 517 | 531 | 596 | 649 | 722 | 737 |

[**Source:** Service/Agency Secondary Item Stratification Data]

Based on the information above, the pattern of procurement leadtime growth in the DoD is clear. Administrative leadtimes have increased by 104% over the period, hwile production leadtimes have grown by 23%. The DoD budgetary requirement related to these procurement leadtimes has tripled since FY 1983, increasing from about $8 billion in FY 1983 to $24 billion in FY 1988. Moreover, the absolute level of procurement leadtimes is significant in that extremely long procurement leadtimes impose very real operating constraints on the ability of the DoD logistics system, and indeed of any logistics system, to respond to change and change, in force structure, modernization, support requirements, and customer demand, has been a major element of the DoD operating environment since 1980. What has not been fully-appreciated, however, is the far-reaching impact of long procurement leadtimes throughout the DoD logistics system. Indeed in many ways, procurement leadtime has been the *forgotten factor* in many otherwise successful[2] acquisition improvement initiatives.

## CONCEPTUAL FOUNDATIONS

**General.** Stark[3] has recently argued that **time** represents the next competitive battleground in the international marketplace and that Japanese firms have already begun to emphasize time management and system responsiveness and flexibility in emerging corporate strategies and operating systems. Indeed, since the early 1980's many firms both in the U.S. and elsewhere have been moving aggressively to drive down processing times of all types throughout their logistics systems in order to reduce operating costs, increase flexibility, and improve customer service. Most of the so-called Just-In-Time (JIT) logistics management philosophies have a common element-specifically the elimination of processing delays and variances wherever possible in the material flow to and through the firm.[4] Integrated processing systems which use information more intensely, selective utilization of rapid transportation resources, partnering relationships with vendors, and active demand management have become the norm in many industrial segments for successful firms. As a result of these streamlining efforts, current aggregate U.S. inventory-to-sales ratios in manufacturing have shown a consistent decline since mid-1984. Procurement leadtime represents a key processing segment which is central to the effective operation of any logistics system. As such, it is important to recognize the conceptual impacts of procurement leadtimes on the resulting costs and operating efficiency of the DoD logistics process.

**Inventory Investment.** For many, the relationship between procurement leadtime and inventory investment is diffuse. In fact, it is often believed that the only real impact of longer procurement leadtimes is a lengthening of the planning horizon for materiel acquisition--we simply must start the process sooner. However, in continous-review, reorder point systems which are commonly used to manage DoD secondary items, the linkage between procurement leadtime and inventory investment is conceptually clear. First, longer procurement leadtimes result in a greater investment in safety level inventories held, in part, in these systems to meet unanticipated demand during any given procurement leadtime. Second, more variable procurement leadtimes result in a greater investment in safety level inventories held, in part, in these systems to accommodate unanticipated procurement leadtime variance at any given demand rate. The direct inventory investment costs of such additional investment in safety levels include both the one-time costs of acquiring the material and the continuing costs to hold the additional inventories over time.

**Forecasting Accuracy.** In addition to the direct inventory investment costs associated with longer or more variable procurement leadtimes, there is an indirect cost related to the problem of demand forecasting. With Administrative Leadtimes of approximately one year and Production Leadtimes of one to two years, the typical DoD inventory manager is generally forced to forecast demand for a specific secondary item *as it will exist some two to three years in the future.*

As one might expect, the level of accuracy in such demand forecasts is unlikely to be very good and, indeed, most DoD secondary item demand forecasting systems have extreme difficulty in accurately predicting demand over this lengthy time horizon. Further, in periods of dramatic structural change, modernization, etc., problems of properly anticipating item demand become even more pronounced when the "reaction time" as represented by procurement leadtime is excessive. Poor forecast accuracy further increases inventory investment in safety levels in most DoD inventory management systems in that it increases the standard error in the demand forecast which is used, either directly or in a modified form such as the Mean Absolute Deviation, to develop safety level requirements.

**Risk of Inapplicable Inventories.** As a reaction to long and growing production leadtimes, many DoD inventory managers have chosen to increase the quantity of material ordered in an effort to reduce procurement workload. While initial order quantities are determined using proven Economic Order Quantity (EOQ) approaches, these EOQ's are routinely overriden through the selective use of order quantity floors or minimum order quantities. These minimum order quantities are typically one years's worth or material or more and range up to three year's worth of material. Clearly, routinely buying several years worth of material several years in advance of the projected requirement introduces a substantial degree of risk. This is particularly true when the high degree of demand volatility common to many DoD secondary items is recognized. Even for items designated as "stable- design, stable-demand items" analysis indicates that demand fluctuation of plus or minus 60% or more over a one- year period are very common. In this unstable environment, the size of the order quantity has been shown to be statistically significant in determining the liklihood and magnitude of inapplicable inventories.[5]

**System Responsiveness.** Finally, lengthy procurement leadtimes also reduce the responsiveness of the DoD logistics system to respond to other changes in the support environment, such as reductions in funding, shifts in program priorities, operational changes, emerging technologies, etc. While not directly tied to the basic inventory requirements determination process, the rigidities introduced when leadtimes are excessive limit the ability of the logistics system to react decisively and effectively when required and must be recognized. In addition, lengthy procurement leadtimes unecessarily tie-up scarce funding resources since, in most DoD systems, dollars are committed at the point where the action to procure the item begins and these committed dollars are, in turn, not available to meet other funding needs.

## OBJECTIVES AND METHODOLOGY

**Study Objectives.** The objectives of the analyses reported in this paper were to determine those policy, procedural, and system factors which are most seriously impacting current DoD procurement leadtimes, to compare leadtime management strategies in successful private sector firms to related approaches common to the DoD, and to identify new strategies and systems which have the potential to reduce DoD secondary item procurement leadtimes over the long run.

**Survey Methods and Data Used.** To understand the impacts of procurement leadtime, this study surveyed a wide range of inventory management and procurement systems in both the private sector and the DoD. Essentially three groups of inventory and procurement managers were analyzed:

1) DoD inventory and procurement managers.

2) DoD vendor inventory and procurement managers.

3) Private sector, non-DoD inventory and procurement managers.

Table II below provides a summary of the organizations which were included in the study. As shown, a total of twenty-four separate organizations were included in the analysis across a broad spectrum of commodities ranging from general purpose industrial products, to electronics and aerospace, to heavy equipment, to electrical and hydraulic systems.

**TABLE II[6]**
**Organizations Surveyed**

| | |
|---|---|
| DoD Inventory and Procurement | Nine wholesale inventory managers the Army, Air Force, Navy, and Defense Logistics Agency |
| DoD Vendors | Nine major DoD vendors in electronics and aerospace, and heavy equipment. |
| Non-DoD Private Sector Firms | Two major airlines, one heavy equipment manufacturer, one auto manufacturer, two major electronics firms |

For each of the organizations included in the survey, we developed specific questionnaires to collect not only operating data relating to inventory and procurement management and procurement leadtimes but also management approaches and strategies used to manage these functions. In addition, each of the organizations was visited and interviews were conducted with selected inventory management and procurement executives. In the case of the DoD inventory and procurement managers, we also extracted sample data for approximately 2,500 individual line items. Line item data collected included the following:

1) Inventory management data (forecast demand, inventory requirements, unit price, etc.)

2) Administrative and Production Leadtimes

3) Contract History (vendors, contract prices, contract delivery dates, quantities, etc.)

4) Receipt History

These data were used to develop representative Administrative and Production Leadtime profiles for the separate DoD organizations included in the analysis. The Production Leadtime profiles for sample items provided the basis for our interviews with the DoD vendors who routinely supplied these items.

Finally, we identified a specific group of several hundred engine items which were used by both a major airline and by the Air Force and Navy and bought under identical part numbers from the same vendors. This specific data subset allowed us to more directly quantify the impacts of alternative approaches to leadtime management where market, item, vendor, and other external factors were essentially held constant.

## EMPIRICAL RESULTS

**Private Sector Procurement Leadtime Profiles.** For the private sector firms surveyed, two clearly different procurement leadtime patterns emerge. For those firms who compete almost exclusively in non-DoD markets, procurement leadtimes for items bought which are similar to many of the items used by the DoD ranged from 45 days to approximately one year. Administrative leadtimes of 15 to 30 days were extremely common, while production leadtimes of 30 days to one year were the norm. In addition, we found that the variance in these leadtimes was minimal, averaging less than 10% of mean procurement leadtime values, as a result of very aggressive vendor monitoring and strong contractual incentives against both early and late deliveries.[7] For private sector firms who are primarily DoD vendors, procurement leadtimes of 150 to 500 days were noted as a typical range. Administrative leadtimes and production leadtimes averaged 90 to 120 days and 150 to 400 days respectively. In many ways, DoD vendors mirror many of the approaches and practices of the DoD and, for the items in our survey, the DoD vendor procurement leadtime for these items was about 80% of the observed DoD production leadtime.

**TABLE III**
**Private Sector Procurement Leadtime Profiles**

| | Non-DoD Vendor | DoD Vendor |
|---|---|---|
| Mean Admin. Leadtime | 30 days | 90 days |
| Mean Prod. Leadtime | 120 days | 270 days |
| Mean Procure. Leadtime | 150 days | 360 days |

[Source: Private Sector Survey Data]

**DoD Procurement Leadtime Profiles.** Using our line item sample, together with summary budget data, we also developed procurement leadtime profiles for the nine DoD wholesale managers included in the study. In Table IV below mean values from these profiles are portrayed. As shown, commodity type plays a part in the procurement leadtimes experienced by DoD wholesale managers. However, as a general rule DoD procurement leadtimes are substantially longer than private sector leadtimes regardless of the type of commodity being procured.

**TABLE IV**
**DoD Procurement Leadtime Profiles**

| | Aviation Parts | Heavy Equip. | Common Consumables |
|---|---|---|---|
| Mean Admin. Leadtime | 276 days | 212 days | 156 days |
| Mean Prod. Leadtime | 529 days | 459 days | 202 days |
| Mean Procure. Leadtime | 805 days | 671 days | 358 days |

[Source: DoD Line Item Survey Data]

In addition to disparities in mean procurement leadtimes observed above, we also noted a much higher variance in DoD procurement leadtimes based on actual receipt data.

As shown in Table V, actual material receipts are distributed around the measured procurement leadtime for the item. It is this high level of variance (plus or minus 30% or more) in addition to the lengthy DoD procurement leadtimes which drives safety level investment.

**Sample Data Differences.** Finally, we turn to the sample of items being purchased both by the DoD (the Air Force, Navy, and Defense Logistics Agency) and a major U.S. airline from the same two aircraft engine manufacturers. Using a sample extract of 400 line items, we identified several hundred of these items which, based on identical part numbers used by the DoD and the airline to buy the item and a review by DoD and airline technical experts, were

**TABLE V**
**DoD Procurement Leadtime Variance**
(Actual as a Percentage of Measured Procurement Leadtime)

| | |
|---|---|
| 0-50% | 16.6% |
| 51-90% | 31.4% |
| 91-100% | 12.5% |
| 101-110% | 8.8% |
| 111-150% | 17.9% |
| 151-200% | 6.0% |
| Over 200% | 6.8% |

[Source: DoD Line Item Survey Data]

determined to be the same items. Table VI below presents the results of our analysis of these specific items.

**TABLE VI**
**Line item leadtime comparison**

| | Airline | DoD | DoD to Airline Ratio |
|---|---|---|---|
| Mean Admin. Leadtime | 30 days | 121 days | 4.0 |
| Mean Prod. Leadtime | 64 days | 315 days | 4.9 |
| Mean Procure. Leadtime | 94 days | 436 days | 4.6 |
| Mean Inventory Investment[8] | $100 | $214 | 2.1 |

[Source: DoD Line Item Survey Data and Airline Inventory Data]

**Conclusions.** From the empirical analyses reported above, we conclude that as a general rule DoD wholesale managers experience longer and more variable procurement leadtimes than well-managed private sector firms who compete in non-DoD markets. Moreover, these leadtime disparities exist even when the item procured, the vendor, and the external market conditions are held constant. Moreover, we find that DoD vendors are, as a group, less effective in leadtime management than non-DoD private sector counterparts. Thus, it may be argued based on our empirical results that it is those DoD management strategies, policies, and procedures which link the DoD and its major vendor community which are responsible for the procurement leadtime differences observed and that to understand the reasons for the differences one must analyze these underlying management issues.

## MANAGEMENT IMPLICATIONS

**Leadtime Measurement.** Clearly, if procurement leadtime plays such a major factor in the requirements determination process, it is imperative that leadtime information used in the DoD inventory management and procurement processes be as valid and accurate as possible. Our analysis indicates that DoD procurement leadtimes are often the result of management decisions to either anticipate leadtime changes or to constrain leadtime budget requirements. Such management decisions are generally implemented by the mass overlay of procurement leadtime data without respect for individual item characteristics. As a result individual item procurement leadtime data is likely to be distorted. Further, use of the Contract Delivery Date as an overlay for procurement leadtime ignores the fact that a large percentage of most orders for secondary items are delivered within the Contract Delivery Date.

**Leadtime Negotiation.** Private sector firms who have successfully established a leadtime management program actively negotiate leadtimes with prospective vendors and typically make leadtime a competitive variable in solicitations in an effort to reduce the total cost, not price, to the firm.[9] The DoD inventory management and procurement systems, however typically accept procurement leadtime as a given and leadtime reduction is seen as the responsibility of neither the inventory manager nor the buyer. In fact, past Contract Delivery Dates are often used to establish required delivery dates for future procurement actions. With leadtime essentially a given, and product quality dictated by item specifications, the DoD procurement process thus concentrates almost exclusively on price as the sole factor in award decisions--often at a higher overall[10] cost to the government.

**Requirements Determination.** Until DoD procurement leadtimes can be substantially reduced, it is imperative that the requirements determination process recognize the extremely long horizon which now typifies most secondary item procurements. Given the dynamic nature of the operating environment, flexibility in order quantity size and the ability to routinely adjust these order quantities over the lengthy procurement leadtime cycle are essential. Based on vendor information on price-quantity alternatives available, the DoD requirements determination process should be restructured to routinely determine the most cost-effective buy quantity at the time of award not at the time the purchase request is initiated, which may be a year or more before award.

**Sourcing Strategies.** Many of the successful private sector firms surveyed have separated the sourcing decision from the buying process for items carried in material inventories in order to minimize administrative leadtimes in reorder processing. Vendors are competitively evaluated as a part of the sourcing process and, once qualified, efficient order processing procedures and systems are established to allow the rapid transmission of routine orders to these qualified vendors. Business may be rotated on some agreed to basis or may be guaranteed to the vendor or vendors who were selected through competitive sourcing. The DoD, in contrast, generally treats each replenishment order for secondary items as a "cold start" process and begins action only after the reorder point is reached and a specific buy requirement is identified. In this sequential process, the validation of technical data, sourcing, and award decision all contribute to the very long administrative leadtimes observed.

**Procurement Methods.** Our analysis indicates that private sector firms who have successfully reduced procurement leadtimes use a wider range of more-tailored buying methods than do their DoD counterparts. In some instances, these buying methods are highly automated and standardized and may involve the electronic transmission of purchase orders. In other cases, where market structure, technical requirements, and other factors limit the number of potential vendors, the private sector firm may buy from a single supplier under long-term contracts. For high usage, stable-demand items, multi-year buying techniques are employed with competitive sourcing to several vendors and actual vendor performance may be used to allocate business over the contract period. The common element in all these approaches is that the buying method used is geared directly to the market in which the item is purchased and the individual characteristics of the item itself. The DoD secondary item procurement process, by comparison, generally determines the appropriate buying method based primarily on the dollar-value of the procurement and the use of tailored, innovative buying approaches linked to the market and the item have traditionally been the exception rather than the rule.

**Vendor Relations.** Finally, our study revealed a significant difference in basic vendor relations in those private sector firms who had successfully reduced procurement leadtimes.

On the one hand, information regarding anticipated demand, maintenance plans, and stocking policies is routinely exchanged in order to reduce uncertainty and allow for better material planning by both the supplier and the buyer. At the same time, vendor performance is closely monitored and evaluated and contract incentives are aggressively used to manage vendors. In comparison with the DoD, the relationships with vendors are far more open and more active during the contract period, but these relationships are also highly competitive is terms of performance and long-term benefits.

## CONCLUSION

In conclusion, the analysis presented in this paper argues strongly for the establishment of an active procurement leadtime management program within the DoD, a leadtime management program which not only explicitly recognizes the vital importance of procurement leadtimes on the effective management of the DoD logistics system but which also incorporates the precept that only through *joint action* in both inventory management and procurement can any substantive improvements be achieved. Such a leadtime management program must challenge basic ways of doing business within the DoD and will require greater flexibility and focus in both inventory management and procurement. Further, the program must recognize that ultimately it is the long-term cost to the government, not price or the number of bidders, by which our effectiveness should be measured. In private sector firms where such a leadtime management effort has been successful, the single common ingredient was highly visible, very active, continuing involvement by top management. The successful programs were driven directly from top management and while, as we have seen here, there are a number of central policy and procedural themes which characterize these firms, it is the motivation and guidance from the executive level, not specific program structure, which dictates success.

## ENDNOTES

1/ See James H. Perry, Andrew A. Giordano, and John F. Olio, "Inventory Management: Beneficial Practices from the Private Sector," Logistics Management Institute, 1985; James H. Perry, Inta A. Silins, and Lloyd B. Embry, "Procurement Leadtime: The Forgotten Factor," Logistics Management Institute, 1986; and James H. Perry, Inta A. Silins, and Douglas W. Brown, "Dynamic Order Quantity: An Alternative to Traditional Economic Order Quantity Methods," Logistics Management Institute, 1988.

2/ Recently, a series of separate programs and initiatives have been originated both by The Office of the Secretary of Defense (OSD) and at the Service/Agency level to address elements of leadtime growth. Most of these initiatives have been directed at Administrative Leadtimes. A very limited number have been directed at reducing Production Leadtimes.

3/ George Stark, Jr., " Time--The Next Source of Competitive Advantage," *Harvard Business Review*, July-August 1989, pps. 41-51.

4/ For a discussion of the impact of JIT strategies on firm behavior and operating performance see James H. Perry, "Firm Behavior and Operating Performance in Just-In-Time Logistics Channels, *Journal of Business Logistics,* Vol. 9, No. 1, pps 19-33.

5/ See Inta A. Malis and James H. Perry, "The Impact of Order Quantity Size on Unneeded Inventories: An Empirical Analysis," *Journal of Business Logistics* (forthcoming).

6/ By agreement, the identities of the private sector companies who participated in the analysis are not available.

7/ It should be noted that these procurement leadtimes do not consider items used in routine manufacturing processes and acquired from external vendors or other internal divisions under true JIT methods.

8/ For every $100 dollars invested by the airline in safety level inventory, the DoD invests about $ 214 for the same item bases strictly on procurement leadtime differences alone.

9/ See David N. Burt, "Managing Suppliers Up To Speed," *Harvard Business Review*, July-August 1989, pps.127-135, for an interesting discussion of private sector vendor management.

10/ The Navy has recently begun to selectively consider vendor production leadtime in solicitation and award decisions and leadtime is now being used as a specific negotiation factor in some Navy secondary item procurements.

# SIMULATION OF PROCUREMENT WORK DIRECTIVE WORKFLOW AT ARMY MAJOR SUBORDINATE COMMANDS

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## ABSTRACT

Army Material Command (AMC) Major Subordinate Commands (MSCs) are failing to accomplish their Procurement Appropriation Army Secondary (PAA-2) obligation plans and are experiencing significant increases in Procurement Administrative Lead Time (PALT). PALT, the number of calendar days from the acceptance of a Procurement Work Directive (PWD) by a Procurement and Production Directorate (PPD) to contract award, minus those days the PWD was delayed due to conditions external to the procurement process, has increased despite additional personnel. Manpower distribution is a suspected cause of this increase. As this PALT definition does not consider procurement time spent on cancelled and "in process" PWDs, one is proposed that does, to provide a more realistic analysis of PWD processing.

A computer simulation model is developed for estimating PPD manpower requirements based upon procurement workload and other factors which might improve the award process at the Army Missile Command (MICOM). The model enables simulated realignments of PPD personnel at major PWD processing points to be performed to assess their effects on PALT and procurement backlog. For a given PPD total server level, that manpower allocation generating minimal PALT and procurement backlog is declared optimal.

Reductions in MICOM PALT appear possible if PPD manpower is reallocated as suggested by the simulations. Applicability of the model to other types of procurement actions at MICOM and the remaining MSCs appears warranted.

## INTRODUCTION

### Background

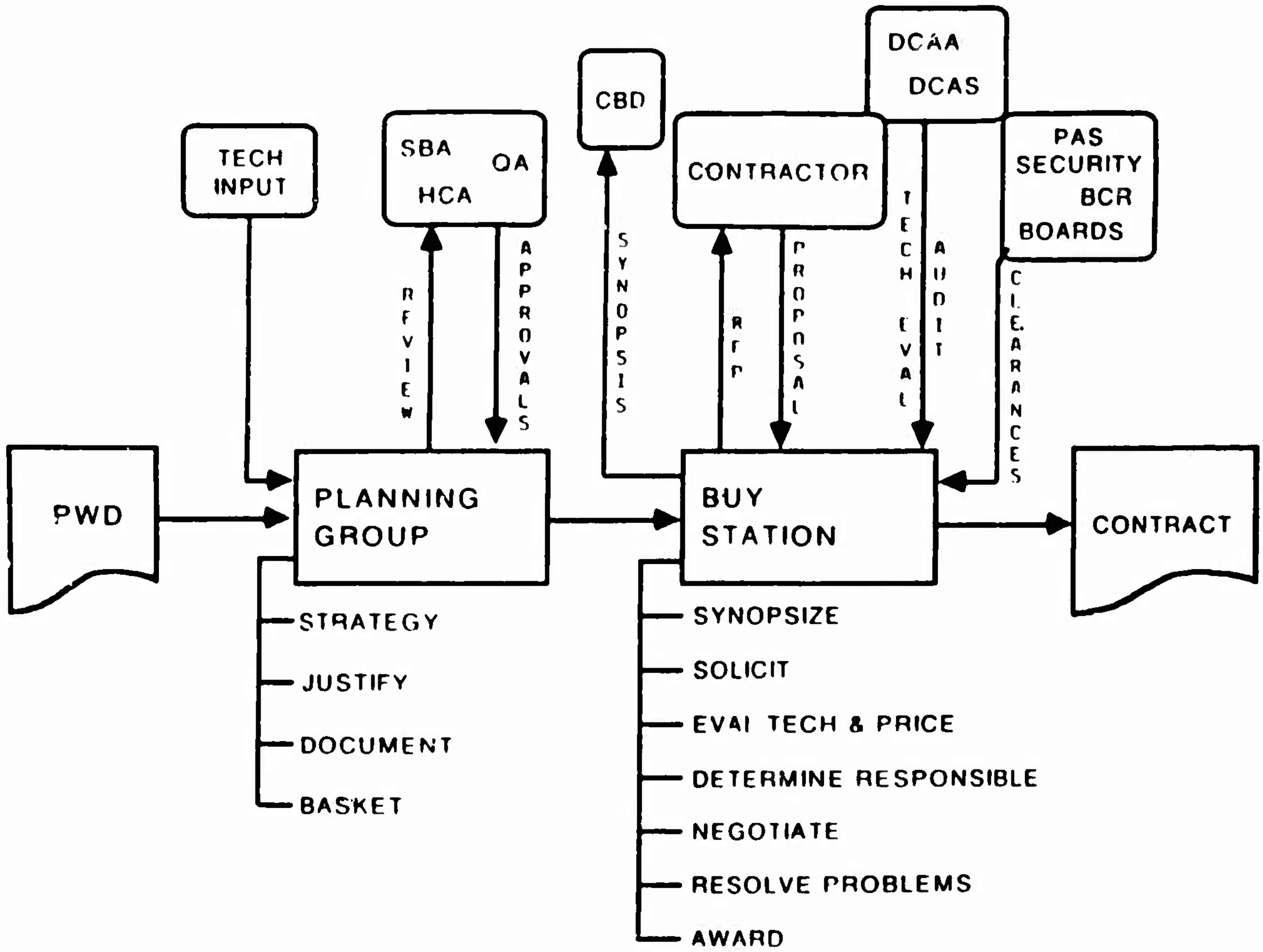
PPDs maintain historical data on PWD processing times which are used by Headquarters AMC to develop PALT standards. These standards, however, do not detail times consumed by individual PALT components or specific instrument types. Consequently, it is difficult to assess the causative factors behind the failure to achieve the planned PAA-2 obligation rate. This study estimates the effect of manpower distribution on the award process. Of particular interest is the number of personnel required to be added or deleted at each major processing point in the procurement process to reduce PALT.

An overview of the MICOM PAA-2 PWD flow process appears at Figure 1. The actual flow is composed of hundreds of interacting processing points and routing conditions. The flow was developed in FY85, in conjunction with AMC and MICOM procurement officers, and is based on AMC's Acquisition and Procurement Task Force Report. [1, 3] A PWD arrives at the Planning Group, where its planning type category is determined: value not exceeding $5000 (sent directly to the Buy Station), Special Buy, Urgent Small Purchase, Urgent Large Purchase, Routine Small Purchase, or Routine Large Purchase ($25,000 threshold). Planning type category flow terminates at the Buy Station. Buy Station PWD categories are Small Purchase Procedure, Priced and Unpriced Basic Ordering Agreements, Request for Proposal, and Invitation for Bid. Buy Station flow terminates at contract award.

It is generally not cost effective to assess the impact of PPD manpower reallocations on PALT by physically realigning personnel. Computer simulation modeling permits repeated artificial realignments and estimates their effects on PALT. Simulation techniques are used in "What if ...?" situations; e.g., "What would happen to PALT if personnel were realigned as follows: ...?" Simulation modeling requires the system under study (MICOM PAA-2 process flow) be described in a fashion compatible with a computing system. If the system can be characterized by a set of variables (the number and type of PWDs, their processing times, etc.), with each combination of variable values comprising a unique state of the system, then altering these values represents system state-to-state transition. Simulation is the representation of the dynamic behavior of the system by moving it from state to state according to well defined operating rules. [2]

FIGURE 1

# PWD FLOW PROCESS




Simulation languages provide a natural framework for simulation modeling. The Simulation Language for Alternative Modeling (SLAM) was chosen as the simulation language for modeling MICOM secondary item procurement, as it offers a variety of modeling approaches. All simulations were performed using SLAM on a SPERRY 5000/80 minicomputer at the Army Procurement Research Office, Fort Lee, VA.

Study Objective

The objective is to develop a realistic computer simulation model of the FY85 MICOM PAA-2 process.

Approach

Computer simulation techniques were utilized to develop a PWD model and evaluate its portrayal of the MICOM award process, using test data provided by the study sponsor, AMC Assistant Deputy Chief of Staff for Procurement (ADCS-P). The MICOM PWD process flow was transformed into SLAM computer code [3, 4]. MICOM procurement workload and manpower data were analyzed to develop hypotheses on relationships between model elements. These relationships were used to apply the model to the PWD process to estimate optimal workforce factors.

Although, in this study, a "purchase action" denotes a batch (collection) of PWDs with identical Product Numbers (PNs), "PWD" and "purchase action" are used interchangeably to avoid notational complexities, with the context determining the appropriate terminology.

## MODEL DESIGN

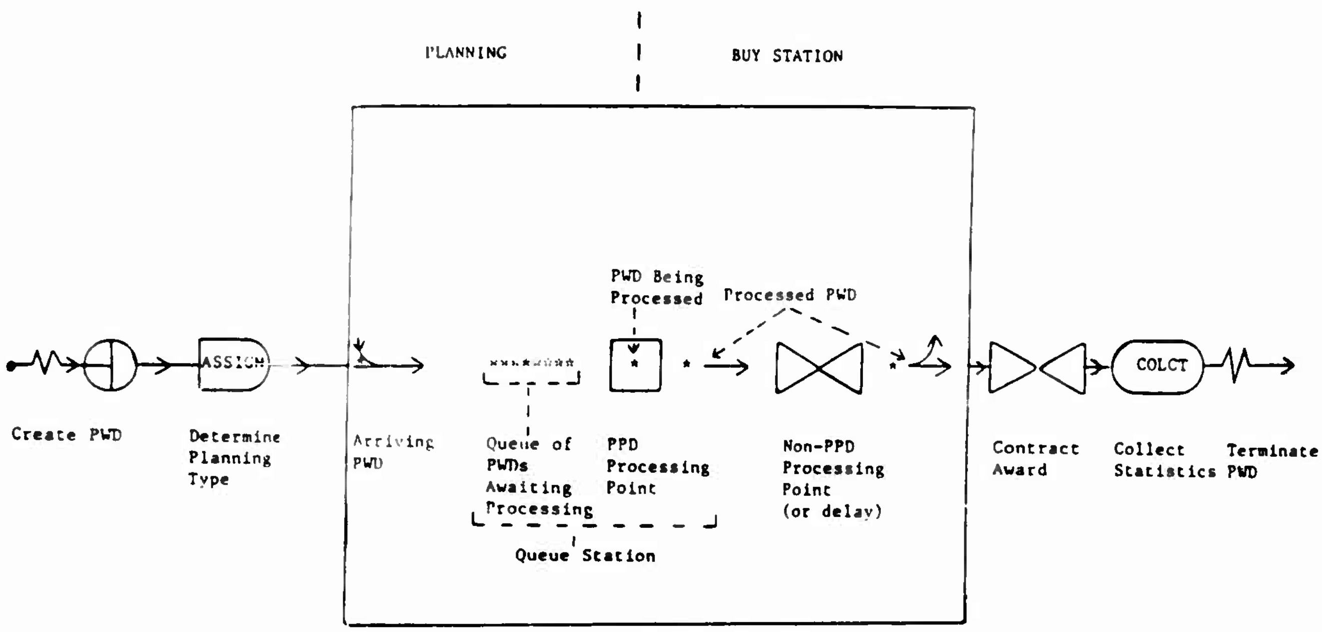
Modeling the MICOM PAA-2 process requires specifying PWD arrival patterns, cancellations, prioritization based on Issue Priority Designator (IPD), batching effects, non PPD processing, and various assumptions as to system operation. The program code must be flexible tc permit updating, as required. An overview of the model structure appears at Figure 2.

PWD Arrivals

Although several probability distributions were examined to assess their suitability to estimate PWD arrival rates, it was discovered model output was relatively independent of the distribution utilized; PWDs piled up at PPD processing points (i.e., "queue stations") regardless of the distribution utilized. It was the time PWDs spent in queues, not the time they arrived to queues,

FIGURE 2

**MICOM MODEL STRUCTURE**




Appropriate Set of Concurrent/Sequential Actions for Each PWD Type

(Format May Repeat)

that had a dominant effect on PALT. Arrival rates of entities to queuing systems often follow Poisson distributions. SLAM utilizes interarrival rates instead of arrival times. As these concepts are reciprocals of each other, and as Poisson arrival rates with mean M correspond to exponential interarrival rates with mean 1/M, PWD interarrival rates were fitted (estimated) with exponential distributions, as follows.

The number of arriving PWDs was totaled for each month of simulated time. Each such total was divided by the total number of hours in the corresponding month; the figure obtained equaled the average number of PWDs arriving per hour that month. The reciprocal of this figure yielded the average hourly time between PWD arrivals for that month. It was assumed the interarrival rate for each month possessed an exponential distribution with a mean equal to the corresponding average interarrival time. The arrival pattern for each month was replicated for each corresponding month for an additional three years of simulated time. For example, October 1984 arrival data was "cloned" and utilized for October 1985, 1986, and 1987 simulated time frames. The simulations did not use actual FY86, 87, and 88 data; it was the FY85 data that was repeatedly utilized. Many simulation studies do not allow the system under study to start "empty and idle;" the system is allowed to "warm up" by clearing all statistical output data arrays at some specified point early into the simulation. However, to provide a sound audit trail (to ensure all PWDs were accounted for), it was decided not to clear the arrays. By extending the simulation over an additional three years of simulated time, and averaging PALT output over this extra period, the "bias buildup" was reduced, and output stabilized.

Cancellations

It was assumed approximately 30 percent of all PWDs cancelled, and a cancellation occurred, with uniform probability, at any time remaining during the FY in which such PWD was created. However, the time at which the model actually "erased" a cancellation depended upon the location of the PWD in the process flow. Cancellation occurred only when the cancellation time had been reached (or surpassed), and the PWD was about to be processed by PPD personnel. The cancellation of a purchase action containing more than a single PWD required that the cancellation be triggered by the "earliest" cancellation in the batch.

PWD Prioritization

The model prioritized PWDs based upon IPD. IPD 2-6 Special Buy PWDs were processed prior to Urgents, and Urgents prior to Routines. For example, of two Urgents awaiting processing, that which had arrived to the queue station the first would be processed next.

Batching

The model batched PWDs by simulated PN code, with PWDs belonging to the same batch only if they possessed identical PNs. All batches were "held" for a fixed time period (30 or 100 days). Upon expiration of each holding period, all batches are released, with the PWDs in each batch continuing onward through the process flow as a single purchase action. Accumulated PALT spent on a PWD is the current simulation time minus the PWD's creation time (i.e., its simulated arrival time to the PPD), after making all time adjustments required by non PPD processing. However, if a purchase action is composed of more than one PWD (i.e., a "batch"), this definition requires modification. It can be shown that if "batch creation time" is defined as the average creation time of all PWDs composing the batch, then a reasonable concept of batch PALT is "current time minus batch creation time."

Non PPD Processing

Tabulations of non PPD processing were incorporated into the model. While, for example, it is not the objective of this study to conduct a manpower reallocation of legal resource personnel, the time spent on obtaining a legal review is a PWD delay contributing to PALT.

Assumptions

Implicit throughout model design were the assumptions as to system operation: a) the developed PWD flow reasonably reflected FY85 PAA-2 process flow; b) all PWD processing times were in hours, to minimize computer rounding error; all time output was in days; c) the curve fitting technique utilized to estimate PWD arrivals reasonably approximated the true PWD arrival pattern; d) all PPD servers at each processing point were competent to service any PWD arriving to their station; their processing times were assumed to be notional "hands-on" times; actual service times may have required augmentation due to servers occasionally being idle; e) all non PPD processing followed triangular probability distributions, as these functions account for different skill levels; f) approval functions were formulated to prevent the occurrence of infinite looping; e.g., a disapproved PWD returning to the same office after reprocessing was not disapproved again; g) travel times between PPD processing points equaled zero; travel time to the Buy Station was one day; h) two sets of simulated PN codes were utilized, 150 and "infinite;" and i) two batch holding periods were employed, 30 and 100 days, to see what effect batching may have on PALT.

## DATA AND MODEL OPERATION

The model was operated with actual and simulated data. Actual data (provided by ADCS-P) consisted of PWD arrival rates, the number and kinds of PWDs entering the system, the number of PPD personnel assigned to each queue station, "hands-on" PPD personnel PWD processing times, delay times for PWD processing by non PPD personnel, travel times between processing points, and probabilities with which PWDs were routed along various process flow paths.

Four simulated PPD manpower allocations were utilized, using server levels of 147, 159, 171, and "unlimited" (i.e., a server level at each PPD processing point at least as large as the total number of PWDs entering the simulations). A near optimal overall weighted average PALT for each allocation was estimated. By flooding the system with servers, no purchase action had to await processing. This scenario "fired" purchase actions through the system, and PALT was minimized. Thus, for a given batch/holding period scenario, a precise estimate could be made of minimum average PALT obtainable, independent of server allocation. Although this represented an ideal situation, it would be unrealistic to try to isolate a manpower allocation to lower PALT further. However, one could assess the efficiency of a proposed manpower allocation by observing the proximity of its PALT output to this (essentially) minimally obtainable PALT.

Although only 14 PPD processing points were used in the model, personnel at each such point had different processing tasks to perform, depending on what the PWD was, where it came from, and where it had to go. PWDs were often routed back to the same point again and again to undergo different processing. As thousands of possible manpower allocations exist, only major PWD backlog areas were examined. Reallocations were performed to reduce major backlogs, and overall average PALT. This resulted in manpower allocations that were "near optimal," as opposed to "optimal."

Simulation model output depends upon the validity of the assumptions employed, as well as system stability. Unstable systems yield large output changes for small changes in data input. Stable systems yield small changes in output for small changes in input. For a fixed manpower allocation, PWD model output was quite stable, and was relatively unaffected by slight changes in such input data as server processing times, PWD delays, etc. However, if the manpower allocation were altered, even slightly, quite large changes in output were entirely possible; consequently, the model was often quite unstable in this case.

## PROPOSED PALT DEFINITION

At any time, a PWD is awarded, cancelled, or remains in process (i.e., "unfinished"). As PALT has been defined only for PWDs that have been awarded, its definition may be expanded to include cancelled and unfinished items, as these items consume procurement processing time. Suppose 15,000 PWDs are generated: 5000 are awarded, 4500 are cancelled, and 5500 remain unfinished. Awarded actions have an average (strictly defined) PALT of 134 days; cancellations have consumed an average of 50 days of processing; unfinished items have consumed an average of 150. What is their overall average PALT? None of the three averages, alone, realistically estimates this concept. However, by redefining overall average PALT as a weighted average of the average processing time spent for each of the three PWD status types, a more realistic PALT measure is obtained. In this example, it becomes

$$\frac{(5000 \times 134) + (4500 \times 50) + (5500 \times 150)}{15{,}000},$$

or, 115 days, approximately. The commonly used PALT concept (134 days) is not as realistic as the one just proposed, at least if the performance measure is solely the average procurement time spent on an action. This enhanced definition was incorporated into the model as follows.

Procurement time spent on a PWD equals the current time minus the time the PWD entered the process flow (i.e., the time it was created by the model), after subtracting out all non procurement processing. The model maintains a running total of the time each PWD is created. Anytime a purchase action exits the process, its time is accounted for. A PWD counter increases by one every time a PWD is created. Whenever a purchase action exits the process, the number of PWDs comprising it is also accounted for. Consequently, average PALT for all unfinished PWDs at any time TNOW computes as

TNOW - average creation time for unfinished actions; i.e.,

$$\text{TNOW} - \frac{\text{creation time total for unfinished actions}}{\text{number of unfinished actions}}.$$

Letting A = the average number of PWDs comprising an awarded action, C = the average number of PWDs comprising a cancelled action, U = the number of unfinished PWDs, Na = the number of awarded actions, Nc = the number of cancelled actions, Pa = average PALT for awarded actions (customary definition), Pc = average PALT for cancelled actions, and Pu = average PALT for unfinished PWDs, overall average PALT for awarded, cancelled, and unfinished actions can be defined by

$$\frac{A \times Na \times Pa + C \times Nc \times Pc + U \times Pu}{A \times Na + C \times Nc + U}.$$

This definition is time dependent, as PWDs constantly entered and exited the process flow. As such, these values were continuously recomputed throughout each simulation.

## RESULTS

### Simulation Output Formats

SLAM provided three sets of statistics for each server level: Statistics for Variables Based on Observation, File Statistics, and Service Activity Statistics. Statistics for Variables Based on Observation lists the types and number of actions processed, and various PALT variable values for each. File Statistics lists procurement backlog for purchase actions at each of the fourteen PWD processing points (queue stations). Service Activity Statistics lists the number of the PPD personnel at each processing point, server capacity, average server utilization, the number of busy servers, and other server-dependent variables. Due to space limitations, only condensed output is provided here. Table 1 lists the simulated manpower allocations.

Figure 3 graphs overall average PALT for awarded actions for the current allocation of 159 PPD personnel, assuming 150 PNs, and a 30 day holding period. Of the 29,556 actions awarded over the four year period of simulated time, approximately 53 percent had PALT values of at most 40 days, and about 14 percent had values over 400. Would reallocating manpower yield lower PALT?

Figure 4 graphs awarded PALT for the near optimal 159 PPD server configuration, again utilizing 150 PNs, and a 30 day holding period. Of the 31,011 awarded actions, almost 58 percent had PALT values of at most 40 days; almost all of the remaining had values between 40 and 140. This revised allocation appears superior.

Table 1

SIMULATED PPD MANPOWER ALLOCATIONS \1

| Queue Station | Function | Server Levels 147 | 159 \2 | 159 | 171 | Unlimited \3 |
|---|---|---|---|---|---|---|
| 1 | Planning | 5 | 2 | 6 | 6 | 58,748 |
| 2 | Planning | 31 | 17 | 35 | 37 | 58,748 |
| 3 | Planning \4 | 11 | 3 | 15 | 15 | 58,748 |
| 4 | BS Division | 1 | 1 | 1 | 1 | 58,748 |
| 5 | BS Branch A | 27 | 28 | 27 | 29 | 58,748 |
| 6 | BS Branch A | 4 | 4 | 4 | 6 | 58,740 |
| 7 | BS Branch B | 27 | 36 | 27 | 29 | 58,748 |
| 8 | BS Branch B | 4 | 4 | 4 | 6 | 58,748 |
| 9 | BS Branch C | 27 | 34 | 27 | 29 | 58,748 |
| 10 | BS Branch C | 4 | 4 | 4 | 6 | 58,748 |
| 11 | BS Branch A | 1 | 1 | 1 | 1 | 58,748 |
| 12 | BS Branch B | 1 | 1 | 1 | 1 | 58,748 |
| 13 | BS Branch C | 1 | 1 | 1 | 1 | 58,748 |
| 14 | BS Pricing | 3 | 23 | 6 | 4 | 58,748 |

1/ Near optimal unless stated otherwise.
2/ Current (FY85) allocation.
3/ At most 58,748 PWDs were created in the simulations.
4/ BS denotes Buy Station.

Tables 2 through 5, respectively, list simulated average PALT for the 150 batch case, 30 and 100 day holding periods; and the "infinite" batch case, 30 and 100 day holding periods. Figure 5 graphs overall average PALT for these four scenarios. Note that PALT is higher in the "infinite" batch case.

## CONCLUSIONS/SUMMARY

While it appears batching can reduce MICOM PALT, it is the number of distinct PNs that seems to determine the efficiency of batching. The more PNs, the more batches there are. Hence, more purchase actions are released, more have to wait in line for processing, and PALT increases. That is why PALT was higher with "infinite" batching. Of course, the distribution of PWDs among PNs may also influence PALT. The holding period may increase PALT, or decrease it, depending, again, on the number of PNs.

It also appears PALT values are possible that approximate the theoretically ideal minimal values obtained in the unlimited server allocation. It appears additional personnel will not significantly reduce PALT below values obtained from the "near optimal" alignment of the current personnel level. While a decrease of 10 percent of the MICOM PPD workforce may yield acceptable PALT levels, extreme caution is required. The "near optimal" manpower realignments are simulated realignments. They are logical outputs of arbitrarily set simulation scenarios. Their effect on PALT in reality is unknown.

Any study stating the award process may not suffer if manpower cuts were implemented may alarm those who would be directly affected by such personnel actions. It must be re-emphasized that this study did not realign PPD personnel; it simulated such realignments, not realignments of reality, but of a model mimicking reality. Changes in assumptions, flow chart validity, etc., would yield different outputs. Recall computer simulation models imitate reality; their output is a function of their program code.

Two critical elements utilized in developing the model were the assumptions of system operation and the performance measure used as the focal point of this study, overall average PALT for awarded, cancelled, and unfinished actions. Entirely different PALT results could have been obtained had one desired to minimize, say, overall average PALT for Urgent Large Purchases, or for other PWD types; a manpower allocation optimal for one set of PWD types may not be for another.

The following is suggested to assist policy makers on this extremely complicated, and sensitive, issue. The "near optimal" manpower allocation of the 159 servers should be reviewed, and any additional constraints evaluated and incorporated, if necessary, into the model. This allocation (or a similar one) should be implemented on a trial basis. If PALT increases, revert to the original manpower allocation, or hire additional personnel. If PALT decreases, implement the "near optimal" alignment of 147 servers, and continue. If PALT increases, revert to the first reallocation. Otherwise, continue with fewer personnel, until PALT stabilizes at some minimal value.

Figure 3

AWARDED PALT

(Current 159 Server Allocation; 150 Batch Case; 30 Day Batch Hold)

```
 OBSV   RELA   CUML      UPPER
 FREQ   FREQ   FREQ   CELL LIMIT    0         20        40        60        80        100
                                    +    +    +    +    +    +    +    +    +    +    +
    12   .000   .000   .2000E+02    +                                                 +
 15759   .533   .534   .4000E+02    +***************************                      +
  1936   .066   .599   .6000E+02    +***                          C                   +
  1899   .064   .663   .8000E+02    +***                             C                +
   414   .014   .677   .1000E+03    +*                                C               +
   701   .024   .701   .1200E+03    +*                                 C              +
   618   .021   .722   .1400E+03    +*                                  C             +
   288   .010   .732   .1600E+03    +                                    C            +
   303   .010   .742   .1800E+03    +*                                   C            +
   316   .011   .753   .2000E+03    +*                                    C           +
   256   .009   .761   .2200E+03    +                                     C           +
   232   .008   .769   .2400E+03    +                                     C           +
   269   .009   .778   .2600E+03    +                                      C          +
   313   .011   .789   .2800E+03    +*                                     C          +
   306   .010   .799   .3000E+03    +*                                      C         +
   370   .013   .812   .3200E+03    +*                                       C        +
   341   .012   .823   .3400E+03    +*                                       C        +
   350   .012   .835   .3600E+03    +*                                        C       +
   306   .010   .845   .3800E+03    +*                                        C       +
   306   .010   .856   .4000E+03    +*                                         C      +
  4261   .144  1.000         INF    +*******                                          C
   ---                              +    +    +    +    +    +    +    +    +    +    +
 29556                              0         20        40        60        80        100
```

Figure 4

AWARDED PALT

(Near Optimal 159 Server Allocation; 150 Batch Case; 30 Day Batch Hold)

```
 OBSV   RELA   CUML      UPPER
 FREQ   FREQ   FREQ   CELL LIMIT    0         20        40        60        80        100
                                    +    +    +    +    +    +    +    +    +    +    +
     7   .000   .000   .2000E+02    +                                                 +
 17853   .576   .576   .4000E+02    +*****************************                    +
  2639   .085   .661   .6000E+02    +****                            C                +
  4017   .130   .791   .8000E+02    +******                                 C         +
  1252   .040   .831   .1000E+03    +**                                       C       +
  1952   .063   .894   .1200E+03    +***                                         C    +
  1426   .046   .940   .1400E+03    +**                                            C  +
   803   .026   .966   .1600E+03    +*                                              C +
   472   .015   .981   .1800E+03    +*                                               C+
   335   .011   .992   .2000E+03    +*                                                C
   160   .005   .997   .2200E+03    +                                                 C
    61   .002   .999   .2400E+03    +                                                 C
    22   .001  1.000   .2600E+03    +                                                 C
     7   .000  1.000   .2800E+03    +                                                 C
     4   .000  1.000   .3000E+03    +                                                 C
     1   .000  1.000   .3200E+03    +                                                 C
     0   .000  1.000   .3400E+03    +                                                 C
     0   .000  1.000   .3600E+03    +                                                 C
     0   .000  1.000   .3800E+03    +                                                 C
     0   .000  1.000   .4000E+03    +                                                 C
     0   .000  1.000         INF    +                                                 C
   ---                              +    +    +    +    +    +    +    +    +    +    +
 31011                              0         20        40        60        80        100
```

Table 2

SIMULATED MICOM PAA 2 AVERAGE PALT

(150 Batch Case; 30 Day Holding Period) \1

| PWD Type\Server Level | 147 | 159 \2 | 159 | 171 | Unlimited |
|---|---|---|---|---|---|
| $5000 or less | 35 | 35 | 35 | 35 | 35 |
| Special Buy | 111 | 409 | 107 | 108 | 105 |
| Urgent Small Purchase | 66 | 66 | 64 | 66 | 66 |
| Urgent Large Purchase | 143 | 142 | 142 | 142 | 141 |
| Routine Small Purchase | 58 | 345 | 58 | 57 | 55 |
| Routine Large Purchase | 144 | 291 | 143 | 143 | 142 |
| Awarded Actions | 58 | 142 | 57 | 58 | 57 |
| Cancelled Actions | 49 | 247 | 50 | 49 | 50 |
| Unfinished Actions | 56 | 176 | 58 | 55 | 60 |
| All Actions | 55 | 129 | 55 | 55 | 55 |

1/ Estimated, potential, average PALT. Server allocations "near optimal," unless stated otherwise. PALT values in days.
2/ Current (FY85) allocation.

Table 3

SIMULATED MICOM PAA 2 AVERAGE PALT

(150 Batch Case; 100 Day Holding Period) \1

| PWD Type\Server Level | 147 | 159 \2 | 159 | 171 | Unlimited |
|---|---|---|---|---|---|
| $5000 or less | 35 | 35 | 35 | 35 | 35 |
| Special Buy | 74 | 434 | 74 | 74 | 71 |
| Urgent Small Purchase | 67 | 67 | 67 | 67 | 68 |
| Urgent Large Purchase | 144 | 142 | 143 | 144 | 143 |
| Routine Small Purchase | 58 | 325 | 57 | 58 | 56 |
| Routine Large Purchase | 145 | 272 | 145 | 143 | 143 |
| Awarded Actions | 51 | 104 | 50 | 51 | 50 |
| Cancelled Actions | 48 | 239 | 49 | 50 | 50 |
| Unfinished Actions | 51 | 307 | 50 | 49 | 48 |
| All Actions | 49 | 180 | 50 | 50 | 50 |

1/ Estimated, potential, average PALT. Server allocations "near optimal," unless stated otherwise. PALT values in days.
2/ Current (FY85) allocation.

Table 4

SIMULATED MICOM PAA-2 AVERAGE PALT

(Infinite Batch Case; 30 Day Holding Period) \1

| PWD Type\Server Level | 147 | 159 \2 | 159 | 171 | Unlimited |
|---|---|---|---|---|---|
| $5000 or less | 40 | 35 | 43 | 37 | 35 |
| Special Buy | 136 | 401 | 128 | 122 | 107 |
| Urgent Small Purchase | 66 | 66 | 66 | 65 | 65 |
| Urgent Large Purchase | 143 | 142 | 142 | 144 | 141 |
| Routine Small Purchase | 85 | 344 | 78 | 68 | 56 |
| Routine Large Purchase | 163 | 285 | 158 | 153 | 143 |
| Awarded Actions | 93 | 183 | 90 | 84 | 75 |
| Cancelled Actions | 60 | 238 | 58 | 54 | 51 |
| Unfinished Actions | 65 | 297 | 59 | 57 | 52 |
| All Actions | 86 | 219 | 83 | 78 | 71 |

1/ Estimated, potential, average PALT. Server allocations "near optimal," unless stated otherwise. PALT values in days.
2/ Current (FY85) allocation

Table 5

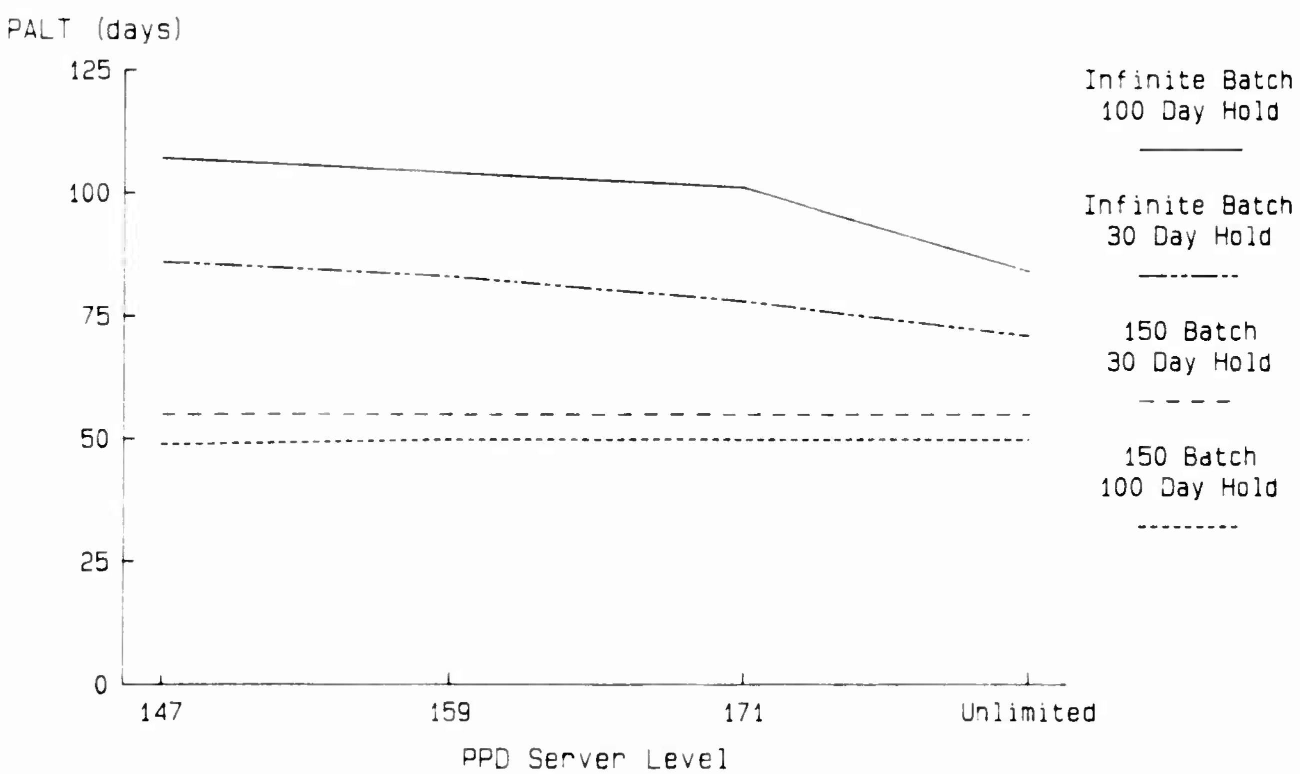
SIMULATED MICOM PAA-2 AVERAGE PALT

(Infinite Batch Case; 100 Day Holding Period) \1

| PWD Type\Server Level | 147 | 159 \2 | 159 | 171 | Unlimited |
|---|---|---|---|---|---|
| $5000 or less | 30 | 35 | 38 | 36 | 35 |
| Special Buy | 191 | 459 | 182 | 177 | 138 |
| Urgent Small Purchase | 68 | 68 | 68 | 67 | 67 |
| Urgent Large Purchase | 144 | 142 | 142 | 143 | 142 |
| Routine Small Purchase | 97 | 369 | 86 | 82 | 56 |
| Routine Large Purchase | 171 | 305 | 165 | 161 | 143 |
| Awarded Actions | 114 | 198 | 110 | 107 | 88 |
| Cancelled Actions | 87 | 245 | 85 | 84 | 68 |
| Unfinished Actions | 88 | 315 | 79 | 77 | [illegible]6 |
| All Actions | 107 | 236 | 104 | 10[illegible] | 84 |

1/ Estimated, potential, average PALT. Server allocations "near optimal," unless stated otherwise. PALT values in days.
2/ Current (FY85) allocation.

# FIGURE 5
# SIMULATED MICOM PAA-2 AVERAGE PALT
# (All Actions)




Based upon FY85 data.
Near optimal server allocations.

The effects that actual manpower realignments have on PALT, contrary to simulated ones, are often long in forthcoming. Consequently, the PWD system flow may change in the process, thereby invalidating simulated results. However, is it better to have results that are tentative, or no results at all?

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# THE EFFECT OF PRIME CONTRACTOR GUARDIANSHIP ON SMALLER DOD SUBCONTRACTORS

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## ABSTRACT

During a 1988 EIA-DoD symposium, it became quite clear that most of the significant information being discussed was geared to prime contractor-levels of concern. Very little was said regarding the impact of the significant changes taking place on the smaller DoD subcontractors.

As prime contractors strive to maintain all of the compliance requirements now driven in most high technology contracts, the smaller subcontractors are receiving a lot of mixed signals. As an example, one major prime contract of a sophisticated missile system requires my company to maintain a Mil-I-45208 (1) level of quality performance while their direct competitor (and sharer of contracts for identical equipment) requires my company to maintain a Mil-Q-9858A (2) level of quality compliance. There are, of course, major differences required between these two quality specifications which significantly drive up the costs for one contractor while their competitor gets the identical equipment and performance at a better price.

Each prime contractor takes DoD requirements dictated by contract and tailors a subcontract or management program to ensure that their interpretation of requirements and compliance is maintained by the subcontractor. The subcontractor must respond to a multitude of detailed quality and cost audits from each of their cognizant prime contractors. There is typically little similarity in these audit checklists so that significant costs are driven to verify many redundant characteristics of performance.

Both direct DoD prime contracts and prime contractor quality characteristic checklists can be standardized to improve efficiencies and reduce redundant costs. As an example, if all prime contractors used the evaluation characteristics contained in Handbook H-50, "Evaluation of a Contractor's Quality Program" (3), then consistency of performance capability can be enhanced. We can all save from this approach.


## INTRODUCTION

DLAM 8200.1 "Procurement Quality Assurance" (4) is the official DoD Defense Logistics Agency manual issued for use by personnel responsible for performing DoD PQA functions. It is used for all tiers of subcontractors and prime contractors. The manual is mandatory for use by all Contract Administration Services (CAS) components unless authority to deviate is granted by the cognizant DoD department.

DLAM 8200.1 has been successfully used for many years in providing guidelines for contract administration functions addressing all manner of contract requirements. Procedures and process reviews are detailed in terms of format and approach to contractor surveillance. In essence, the DLAM 8200.1 is the "Bible" for setting up a Quality Assurance Representative business system to verify contractor requirements compliance. The mechanisms for evaluation, reporting, corrective action, waivers, deviations, and material review board activities are all spelled out in this manual. This manual is not typically listed in any formal contract. It is a valuable reference, however, for general contractor use in order to gain the official government perspective on how many of the mechanics of compliance are judged.

Both Mil-Q-9858A, "Quality Program Requirements" and Mil-I-45208A, "Inspection System Requirements" are the typical DoD specifications imposed on prime contractors and most subcontractors. Government Quality Assurance Representatives conduct routine audits of our facility, typically to the highest quality system established within our facility. Government personnel do not issue formal letters "blessing" any quality system, but rather state that at a given time and date, the quality system appeared to meet required performance characteristics. Prime contract QA representatives make frequent performance audit visits both for "buying off" hardware and to verify checklist characteristic performance. Last year (1988), my facility was audited approximately 35 times by various DoD and prime contractor representatives. These audits usually require the complete attention of a Quality Engineer and/or Inspection Supervisor to properly respond to the detailed questions of our customers. On several occasions, we have had two QA audits going on at the same time. The aggravating part of this is that there is no consistency in the audit characteristic checklist. Usually, a thorough audit can take two to three days for Mil-Q-9858A assessments.

## THE SPECIFICATION COMPLIANCE DILEMMA

Mil-Q-9858A has a companion document, the H50 Handbook for evaluation of a contractor's quality program. Mil-I-45208A has an equivalent handbook, H51 (5) for the evaluation of a contractor's inspection system. Both of these specifications make reference to Mil-Std-45662, "Calibration System Requirements" (6), which has its own handbook, H52 (7) to provide evaluation of a contractor's calibration system. The level of imposed specification is dictated by the complexity of the hardware being produced.

For most avionic hardware, both prime contractors and their principal subcontractors usually have a system which meets Mil-Q-9858A performance criteria. Handbook H50 lists each specific Mil-Q-9858A paragraph, and follows each paragraph with a brief review of the requirement. There is then a brief discussion which reviews the application of the requirement, the thrust being the Government's perspective on the requirement. There then follows a detailed criteria for evaluation which typically lists several lengthy questions to structure a government QAR review of the requirement.

Many companies, my own included, have learned a lot over the years and have structured a quality system which is based on the detailed criteria contained in the referenced handbooks. When done properly and maintained, a company can structure its quality system to facilitate the Government representative's understanding of the system which should be using the same definitions and terminology already used by the Government.

Unfortunately, most companies working with DoD, both prime and subcontractors, do not have a quality system based on the referenced specifications and handbooks. Based on the many detailed audit checklists that I have seen during the past several years, it is very clear that each company has spent considerable resources in generating and maintaining complex checklists to measure the performance of themselves and their many key suppliers. These checklists usually include a lot of subjective data and from my experience are almost always overkill in terms of identifying and criticizing perceived system deficiencies.

## CONCLUSIONS/RECOMMENDATIONS

I propose that the Defense Logistics Agency (DLA) arm of DoD aggressively pursue a different course in assessing and maintaining the needed quality consciousness of their many contractors. Let's generate model checklists that are consistent and characteristically well defined so that we can minimize the constant bickering and arguing over strict contract compliance issues.

Everybody has a chance to win in this scenario. Perhaps we can eventually minimize routine source inspections which really drive contract costs. As we step into the 1990s, we must embrace the tenets of Total Quality Management (TQM) as described in the DoD Master Plan for TQM (8). This effort will be an iterative process calling for constant challenge and change to achieve our needed strong and vigilant defense. I believe that consistent characteristic checklists can be created and used when supported by all management levels in industry and DoD.

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# UNDERSTANDING THE GSA-ADP SCHEDULE CONTRACT PROCESS

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## ABSTRACT

The GSA-ADP Schedule Contract is a ba for establishing an approved vendor list for many state and local governments and is sometimes used as a litmus test for Federal government contract procurements. This paper presents a concise overview of the complex government procurement process and specifically addresses all the essential requirements for selling ADP products to the Federal government.

The purpose of the paper is to address the process used to acquire and use a GSA-ADP schedule contract without discussing the fact that similarities in the proposal submission and negotiation process exist under other schedules within the Multiple Award Schedule program. The paper provides insight into the strategies and techniques used in negotiation, contract administration, and marketing needed to implement a GSA-ADP Schedule Contract program successfully within your firm.

## INTRODUCTION

In providing support to Federal government agencies, GSA provides various types of contractual programs with numerous vendor companies. These programs can be used by specific procurement personnel to satisfy their purchasing requirements. These contractual programs come under the heading of "Multiple Award Schedule (MAS) Contract Program" and offer a simplified process for obtaining commonly used supplies and services at fair and reasonable commercial prices for specific order volumes.(1,73)

The MAS Contracts are indefinite quantity contracts established with commercial firms for supplies and services at stated prices for given periods of time. Procurement personnel will issue delivery orders directly to the schedule contractor for the required supplies or services.(1,73)

The goal of the MAS contract program is to provide a procurement method for purchasing government requirements for commercial products and services at prices that are better than they could obtain from any other source under similar circumstances.(1,73)

Under the MAS contract program, there are five types of schedules:

- The Federal Supply Schedule
- The FED Link Library of Congress ADP Schedule
- Teleprocessing Services Schedule
- Medical Supplies and Equipment Schedule administered by the Veterans Administration
- Information Resources Management Schedules (IRMS) - (GSA-ADP Schedule)(2)

Under the IRMS schedules division, there were eight types of schedules, which included five types of communication schedules under Group 58 and three types of ADP schedules under Group 70. This paper will concentrate entirely on the Group 70 schedules for the general purpose ADP equipment and software, which includes personal computers, micro computers, mini computers, and mainframe computer sales and services with total sales of over $2.0 billion on all ADP schedule contracts.(1,73-74)

### Definitions

The GSA-ADP schedule contract is a firm fixed priced non-mandatory indefinite order value contract with the Federal government for goods and services at prices that would be similar to or better than those offered a commercial customer under similar terms and conditions for a specified period of time.(1,74) A non-mandatory schedule does not require the Federal government to purchase any goods or services but may provide an avenue for many vendors to market their products of $50,000 or less without synopsizing the requirements in the Commerce Business Daily (CBD). In addition, this indefinite order value contract gives the vendor community an opportunity to sell products and services to the Federal government without guaranteeing a specific volume of business, but if sales fall below $100,000 for a two year period GSA may not renew or negotiate a subsequent schedule.

### Negotiation Process (GSA Review Process)

As with any solicitation, the GSA-ADP schedule solicitation will contain mandatory clauses and non-mandatory clauses from the Federal Acquisition Regulations (FAR). However, GSA will include some clauses of its own from the General Services Administration Regulations (GSAR) and Federal Information Resources Management Regulations (FIRMR) for vendor review and compliance. In this section, an emphasis will be placed on the mandatory FAR requirements, to which your contracting officer may demand strict adherence during the negotiation process, the discounts offered to general public customers, and commerciality. The three major mandatory regulations to which your GSA contracting officer may require specific adherence are the Walsh Healey Public Contracts Act, Buy American Act, and Price Negotiation provisions.

### Walsh Healey Public Contracts Act (FAR Subpart 22.6)

The Walsh Healey Public Contracts Act requires that a company certify itself as either a dealer or manufacturer in performance of a specific Federal government contract (GSA schedule). Under the statutory requirements of the Walsh Healey Public Contracts Act, all contracts entered into with the Federal government subject to this provision for the manufacture, or furnishing of materials, supplies, articles and equipment exceeding $10,000 shall be with the manufacturer or regular dealers in the supplies manufactured or used in performing the contract.(3,42262)

The term "manufacturer" as used in the regulations means a person who owns, operates, or maintains a factory or establishment that produces on the premises the materials, supplies, articles, or equipment required under the contract and of the general character described by the specifications. The phrase "regular dealer" as used in the regulations means a person who owns, operates or maintains a store, warehouse, or other establishment in which the materials, supplies, articles or equipment of the general character described by the specifications and required under the contract are bought, kept in stock and sold to the publi in the usual course of business.(3,42262)

The major distinction allowed by the manufacturer status as opposed to the dealer certification is that a business may simply plan to do the work and have estimates and arrangements made that prove capability, which is often the case with a commercial company wanting to diversify into Federal government contracting. However, under the dealer designation a company must currently be selling similar items out of inventory and be able to support the proposal under consideration before being awarded a contract.(3,42263-64)

In addition, the manufacturer and dealer status for a commercial company diversifying into the Federal government marketplace allows for the use of its established commerciality; whereas a Federal-government-only dealer or manufacturer will have to provide cost or pricing data to the contracting officer.

Ordinarily, Walsh Healey certification will be routinely reviewed without GSA discussions; however, as a result of organizational changes within the ADP industry such as system integration companies, mergers, and joint ventures, there may be a need for a final determination by the Department of Labor before GSA will entertain negotiations toward a schedule contract.

### Buy American Act (FAR Subpart 25.2)

Another very important regulation that will receive GSA's attention during their review is the Buy American Act. Under the Buy American Act, a domestic end product is an unmanufactured end product mined or produced in the United States or an end product manufactured in the United States, if the cost of its components mined, produced or manufactured in the United States exceeds 50 percent of the cost of all its components. The cost of each component includes transportation cost to the place of incorporation into the end product and any applicable duty even though a duty-free entry certificate is issued. (3,42281)

If the contractor does not pass the first phase of this screening process, GSA will request a list of all your equipment that is of foreign origin and the applicable country to determine whether the product is eligible under the Trade Agreements Act of 1979 (FAR Subpart 25.4). Under the Trade Agreements Act of 1979, agencies shall evaluate offers of $169,000 or more for an eligible product without regard to the restrictions of the Buy American Act if the purchase is from a listed "designated country" and a "designated country end product." "A designated country end product" is an article that is wholly the growth product or manufacture of the designated country or, in the case of an article which consists in whole or in part of materials from another country, has been substantially transformed into a new and different article of ommerce with a name, character, or use distinct from that of the article or articles from which it was so transformed.(3,42283)

As you can see, according to the regulations a product may consist of 100 percent foreign manufacture if no specific restriction has been placed on the country or product. If your company fails on this second screening phase, a last resort would be to find out what the separate memorandum of understanding between the United States and the foreign country states for your specific product. Your firm may be eligible for an exception to the Trade Agreements Act based on the specific memorandum of understanding. Gaining an exception will require a specific waiver issued by GSA; however this waiver is subject to modification or withdrawal by the U.S. Trade representative.(3,42279-80)

## Price Negotiation (FAR Subpart 15.8)

Since the enactment of the Competition in Contracting Act of 1984, GSA has been thoroughly reviewing vendor commerciality, which is defined in the Price Negotiation provisions. Under the Price Negotiation provisions pertaining to commerciality (FAR 15.804.3), GSA provides for an exemption from or waiver of submission of certified cost or pricing data (SF1412) "if prices are based on established catalog or market prices of commercial items sold in substantial quantities to the general public" for GSA schedule contractors.(3,42207)

When GSA has determined that you generally qualify for an exemption, they will review the data submitted with your proposed offer to determine if sales at catalog price to the general public and sales to the general public at other than catalog price comprise over 55 percent of total sales (substantiality test). After the substantiality test is met, GSA demands that 75 percent of total sales to the general public be at catalog price.(3,42208)

Upon failing either of the previous commerciality tests for a particular product or service, the contractor may request the contracting officer to consider an exception by defaulting to 35 percent of total sales to the general public (substantiality test) and that 55 percent of total sales to the general public be at catalog price. If the product or service does not meet the minimum thresholds to establish commerciality, the GSA contracting officer will require that the product or service be eliminated from the schedule offer or that the contractor provide cost or pricing data.(3,42208)

There are various proposals throughout the government suggesting that at least 20 percent of a schedule be non-commercial. GSA appears reluctant to address the issue of making 20 percent of a schedule non-commercial probably because of the price negotiation provisions that allow the contractor to submit cost and pricing data for all items that do not meet the "minimum test of commerciality."

## Discounts Offered to the General Public

During the negotiation process and with the submission of your solicitation, GSA requests a full disclosure of data relative to the discounts offered to the general public customer type by category such as OEMs/VARs, dealers, distributors, national account agreements, and end users. This data will be used to evaluate your solicitation and subsequently form a baseline or strategy from which the contracting officer will request discounts from vendor products. It is imperative that each company negotiator know what category of customer or specific customer his GSA-ADP contract sales and terms resemble prior to submitting the solicitation. The negotiator should have a firm grasp of this rational basis before presenting the solicitation for consideration by the GSA contract officer during negotiations.(1,75)

In addition to discounts per category of customer, the solicitation requires that a schedule contractor provide quantity discounts, aggregate discounts, prompt pay discounts, prompt order renewal discounts, and special item number discounts per product line or service offered to their most favored customers under similar circumstances. A further requirement is estimated sales data per year for each special item number (e.g., 132-1 (Lease), 132-6 (Purchase)).

Once a GSA-ADP schedule contractor has satisfied all the previous requirements, GSA will review your discounts per product line or service offered to the general public under similar sales volumes and terms and conditions to determine an acceptable discount for your schedule. This discount is usually 3 to 5 percent greater than the commercial customer's discount.(2)

## Awarding of GSA-ADP Schedule Contract Number

After GSA has determined that they have received an acceptable aggregate economic benefit, the GSA-ADP schedule contractor will be notified to submit a best and final offer stating the agreed to basis of award, a pricing certification, and the applicable terms and conditions. Presuming that the best and final offer is accepted by GSA, GSA will notify the GSA-ADP schedule contractor by issuing a new schedule contract number or a renewal option of your current schedule.

Many GSA-ADP schedule contractors prefer to submit a new proposal even though they have been offered an option to renew. Often, an option is not exercised because the GSA-ADP schedule contractor assumes that prices may not be increased or new products added, which can be determined by asking your GSA contracting officer.

# Contract Administration

After the GSA-ADP schedule contractor has received an award notification, the contractor must prepare a proof copy of the GSA-ADP schedule price list and terms and conditions for final review and approval by the contracting officer. Once this price list is approved by the contracting officer, the contractor must have the GSA-ADP schedule price list published and sent to the appropriate government agencies.

The contract administration of a GSA-ADP schedule is a continuous and time-consuming process involving the following:

- updating mailing list of GSA schedule customers
- monitoring price reductions and availability status changes for the category of customer used in the basis of negotiation for notification to the contracting officer
- introducing new terms and conditions that your commercial counterpart or supplier offers on accepted GSA products for the category of customer used in the basis of negotiation
- reviewing commerciality for the products offered on the schedule (some vendors may have over 5,000 items)
- negotiating modifications for new products or increases or decreases in geographic scope or support levels
- submitting temporary price reductions (30 days or more)
- renewing maintenance and software licenses on a yearly basis
- submitting sales data (Form 72) on a bimonthly basis
- reviewing and analyzing competitors GSA-ADP schedules
- submitting the annual subcontract business plan report

## Marketing

There are various ways to market ADP products to the Federal government, but the GSA-ADP schedule is the vehicle that establishes a credible baseline contractual agreement with the government and contractor for purchase orders of $300,000 or less or for maintenance orders, which carry no maximum order limitation. Therefore, the GSA-ADP schedule offers an opportunity for continued sales and convenient renewal of maintenance on the installed hardware.

Normally, the government contracting officer does not need additional price support (SF1412) for an item in the GSA-ADP schedule because items have met the test of commerciality, thus providing for more efficient processing of orders of $300,000 or less and price support for various items on open market orders.

Furthermore, if a vendor has a GSA-ADP schedule, prime contractors' may use the pricing in a bid if authorized by the prime contracting officer. This usually occurs on a cost type procurement. When schedule pricing is used, the vendor need not provide price support (SF1411 or SF1412) to the prime contractor.

Your marketing staff can sell products from the GSA-ADP schedule to Federal agencies, mixed ownership Government Corporations, the District of Columbia, the Senate, the House of Representatives, 8(a) set-aside program contractors, and prime contractors. Another interesting characteristic to be noted about the GSA-ADP schedule is that some state and local contracts use it as a basis for accepting bids and negotiating their procurements.(2)

The size of an order that can be written from a GSA-ADP schedule depends on the category and your specific negotiated maximum order limitation. Currently, the total maximum order limitation for purchase of hardware and software is $300,000. A quantity of one on an order is authorized for all items over $300,000, but a GSA Delegation of Procurement Authority (DPA) is required. Hardware maintenance orders have no specified maximum order limitation; however, software maintenance requires an order limitation of no more than $100,000 or 25 percent of an operating system whichever is lesser.

The GSA-ADP schedule requires that orders over $50,000 be published in the CBD for a fifteen day period. After this waiting period, if there is not any competition for the GSA order, the government contracting officer can award the contract to the contractor. However, if competition exists, the government contracting officer must issue an Invitation for Bid (IFB) or Request for Proposal (RFP) in the CBD for 15 more days and then has 30 more days to review and accept the lowest technically qualified bidder with an order issued by the contracting officer by at least the 60th day.(2)

"In most cases obtaining a GSA number can give your firm an advantage because the GSA supply system is a primary source for Federal civilian and military agencies"(4)

You can be assisted by a GSA Business Service Center counselor free of charge to answer marketing related questions regarding a GSA number. A counseling session is highly recommended and will assist your firm in deciding whether GSA's contracting programs are the right marketing move for your firm.(4)

## SUMMARY

The authorized GSA-ADP Schedule is the accepted bible of the government ADP procurement offices; therefore, if contractors understand the process of acquiring and using a GSA-ADP schedule, they will be in a position to develop better strategies and systems that will help to effectively compete, administer, and market ADP products and services for all procurements.

The research indicates that the GSA-ADP schedule is a negotiated contract based on a certain estimated volume of business per year; therefore, when pricing a separate contract or open market order, contractors should be cognizant of the impact that different terms and conditions and proposed values make before deriving a product or service discount.

In addition, the research strongly suggests that any commercial contractor contemplating marketing to the Federal government ADP arena should seriously consider acquiring a GSA-ADP schedule. If the contractor understands the GSA-ADP schedule process, they will have essentially mastered the major Federal Acquisition Regulations. This understanding will be instrumental in future negotiations on major competitive procurements with the Federal government.

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# WIN-WIN RELATIONSHIPS: THE FOUNDATION OF SUCCESSFUL PROCUREMENT REFORM

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## INTRODUCTION

The decade of the 1980's has been a time of increasingly adversarial relationships among the principal players in the defense acquisition process. In an attempt to procure more "bang" for the American taxpayers' "buck," government acquisition officials have created a variety of strategies and techniques designed to reduce or eliminate the opportunity for cost growth on defense contracts.

Few would argue the need to make the best use of taxpayer dollars allocated to defense procurement. Few, even in the defense acquisition arena, would argue the need to reduce the probability of cost growth in defense procurement. Many would argue, however, the propriety of some of the strategies employed during the 1980's to achieve these ends.

This paper will: present a discussion of the concepts of win-win, win-lose, and lose-lose in relation to acquisition strategies and tactics; review some of the strategies and tactics that have been employed during the 1980's, some of which have been discarded while others have been modified; assess those strategies from the perspective of win-win versus win-lose versus lose-lose; and will discuss the implications of the principles of win-win versus win-lose for the procurement reform movement which is currently underway.

## THE WIN-WIN CONCEPT

The concepts of win-win, win-lose, and lose-lose are neither new nor are they original. The terminology is borrowed from the realm of game theory. Simply stated, the concepts imply that in a two-party relationship, actions may be taken which result in benefit to both parties (win-win); which result in benefit to one party at the expense of the other (win-lose); or which are detrimental to both parties (lose-lose).

In a two-party relationship where the parties are independent entities, the choice of strategies and tactics is at the discretion of the individual parties. Frequently, the appropriate choice is based on the expected duration of the relationship and the availability of acceptable alternative partners.

A "classic" example where a win-lose strategy might be appropriate is the situation of a used car dealer and his prospective client. The relationship is characterized by its typical short duration (normally one does not form a lasting business or personal relationship with his used car dealer) and by the endless supply of alternative partners for both the dealer and the prospective client. The appropriateness of the win-lose strategy in this situation is further implied by the expectations of the parties regarding the relationship. That is, the typical used car buyer does not expect "dealer rebates," special service packages, or promises of lasting satisfaction. Nor does the dealer harbor any visions of life-long customer loyalty or substantial repeat business from the buyer. Each expects that this relationship is a "one-shot deal" in which each party will be negotiating to get the best possible outcome in this instance. Since it is a short-term, two-party relationship, whatever one party wins the other must lose and vice-versa. If, in their mutual zeal to obtain the best possible outcome, they fail to reach agreement, all is not lost; the parties each simply move on to the next alternative partner and begin the win-lose process over again. There is nothing immoral, illegal, or unethical in their behavior. In fact, this type of behavior is expected by both parties in the American capitalistic, free enterprise system.

In a relationship which is typically of long duration in which the number of acceptable alternative partners is very limited or non-existent, such as the relationship between the defense department and its suppliers of major weapon systems, a win-win strategy is more appropriate. In fact, I would argue that in such a relationship, win-win is the only acceptable strategy. This argument is based on the logic which states that in a long-term relationship where there is a degree of mutual dependency between the parties, repeated rounds of short-term win-lose behavior ultimately and inevitably lead to a lose-lose outcome.

Let's examine this second scenario more closely. The relationships between the government and its prime contractors of major weapons systems, or between the prime contractors and their subcontractors are generally expected to be of long duration with many negotiations and agreements to be reached over the years. Furthermore, the availability of acceptable alternative partners is definitely limited or non-existent. In this situation, the parties may be independent entities, but they are mutually dependent on each other. The parties establish a relationship from which each expects to benefit. The buyer expects a product of acceptable quality at a reasonable price; the seller expects to have the opportunity to make a reasonable profit from the resources invested. This is the essence of the win-win concept.

If, over the long term, both parties are better-off for having established the relationship, then the relationship is likely to continue.

If, on the other hand, one party is always winning and the other party is always losing, the losing party MUST take action to protect itself. If one party constantly plays win-lose, always seeking to obtain maximum benefit for its own side, it is virtually guaranteed that the other party will retaliate with win-lose strategies of its own. For example, if government procurement policies create a long-term losing situation for industry, industry will react by producing inferior products, missing schedules, over-pricing other products, withdrawing from defense business, requiring government bail-outs, or by declaring bankruptcy--all of which are long-term losses for the government as well. Similarly, if industry wins and the government loses repeatedly over the long-term, the results are sure to be increasingly complex procurement laws, over-regulation, micromanagement, and such things as contract renegotiation boards. Logic leads one to believe that the long-term result of repeated "rounds" of win-lose behavior is a lose-lose outcome, i.e., both parties lose in the long run!

A more complete understanding of the win-win concept can be gained by examining what it is and what it is not:

(a) Win-win does not imply a "cozy" relationship where the contractor or subcontractor is guaranteed a healthy profit, regardless of performance.

(b) Win-win does imply that a contractual relationship is established such that the contractor has the *opportunity* to earn a fair rate of return based on the degree of risk undertaken, the resources invested, and the performance rendered.

(c) Win-win is a "two-way street." One party acting alone cannot establish a win-win relationship. Both parties must exhibit win-win behavior. If one is "playing" win-win while the other is "playing" win-lose, the relationship will degenerate into win-lose for both parties, and ultimately will become lose-lose.

(d) Win-win applies to the creation of acquisition laws and policies that affect broad classes of acquisitions, as well as to individual program strategies, and to individual contracting actions.

(e) Win-win focuses primarily on the long-term, i.e., "What is likely to be the long-term consequence of taking a particular action in the short-term?" In this regard, the concept accommodates a strategy that involves short-term "investment" by either party in order to enhance long-term benefit. In other words, both parties do not have to win equally on every single transaction. One party may be perfectly willing to lose a little on this transaction in order to improve its long-term prospects.

## REVIEW OF SOME STRATEGIES OF THE 1980'S

The decade of the 1980's has seen unprecedented levels of military spending. Over $1.5 trillion will have been spent by defense department contracting officers in these ten years. This decade has also seen equally unprecedented levels of interest in the defense acquisition process. In 1984 alone more than 200 bills were introduced in the Congress designed to "fix" various perceived weaknesses in defense procurement laws and regulations.

Many of the "fixes" have been proposed or dictated by well-intentioned individuals who were unable or unwilling to predict the likely result of their implementation. Some of the "fixes" themselves have had to be "fixed" in future legislation. In some cases, the administration has instituted a "fix" which Congress has come along the very next year and "nixed." Perhaps the aspect of all this fixing and nixing that has been so frustrating and confusing is that a great deal of the activity seems to have been inspired, not so much by a desire to fix anything, as by a desire to show that some action is being taken to prevent some perceived transgression from ever happening again! Furthermore, many of the fixes have clearly been win-lose type actions, taken in response to apparent win-lose actions of the other party.

Among the many procurement policy or statutory actions which fit the description above are the following:

(a) *Action.* In the mid-1980's, in response to stories about defense material which did not perform properly (contractor win-lose), a statute was passed which required extensive procurement of warranties on major weapon systems (government win-lose). While warranties are often a good idea, in many cases the procurement and enforcement of a warranty is either impractical or too expensive. The law itself was too broad, but DoD's implementation was even broader than the law required. To top it off, at least one service began enforcing warranties which never existed and declared that it would not pay extra for contractor warranties (government win-lose).

*Analysis.* Proper use of warranties where the details of the warranty are tailored to the nature of the product and its intended use, and where the contractor is compensated for the additional risk, is a win-win strategy. Overuse and overextension of warranties and refusal to recognize additional cost for accepting additional risk, is a win-lose strategy. This approach will ultimately lead to a lose-lose outcome as contractors raise initial prices to cover their new, nearly unlimited liability or as substantial losses lead to a further reduction in the defense industrial base.

(b) *Action.* The statutory and regulatory changes regarding contractor data rights have probably been more confusing and more often changed than any other aspect of defense procurement in the 1980's. In the early 1980's, the services issued service-specific policy on the procurement of data rights, essentially stating that contractors must, within a specified period of time (five to seven years), sell or give the government certain rights in the contractor's technical data (government win-lose). In 1985 Congress decided to legislate some changes to this technical data policy. Each year, for at least the next two years, Congress again changed the law. In at least one instance, the changes to the law were enacted before the defense department could even implement the last statutory change. The result has been confusion, if not chaos, as DoD has implemented interim changes to interim rules without having been given the time to go through the normal process of obtaining public comment before implementing regulatory change.

*Analysis.* Proprietary information can sometimes represent the life blood of a company (consider the stringent security regarding the formula for coca-cola). Accommodating the government's legitimate need for technical data in the maintenance and reprocurement of products through appropriate safeguards and compensation is a win-win strategy. Forcing a contractor, as a contractual requirement, to forfeit its legitimate data rights is a win-lose strategy that ultimately leads to a lose-lose situation where contractors will not use their best technology in designing defense products for fear of losing competitive advantage in the commercial marketplace. Furthermore, the current situation leads to great uncertainty and complex negotiations over who owns what rights to what data. This situation further slows an already sluggish procurement system.

(c) *Action.* Each of the services has experimented with policies requiring either fixed priced contracts, or cost reimbursable contracts with ceilings or caps on them for research and development efforts (government win-lose). While such contracts may sometimes be appropriate, such a strategy does not make good policy. Congress has now legislated that large dollar value research and development contracts will not be awarded on a fixed price basis without the specific approval of the Under Secretary of Defense for Acquisition. Such legislation should have never been necessary.

*Analysis.* Procurement regulations allow the use of a wide variety of contract types and prescribe careful analysis and selection of the appropriate type of contract for the procurement situation. This is a win-win strategy. Overuse of fixed-price contracts in an attempt to limit the government's cost exposure and the resultant shifting of undue risk to the contractor has been shown over and over again to be a win-lose strategy that ultimately leads to a lose-lose outcome requiring government bailouts, specification reductions, program stretchouts, or even program terminations.

(d) *Action.* In 1985 one of the services decided that contractors should pay the up-front cost for special tooling and test equipment and recover those costs through depreciation. The next year, Congress passed a law requiring that contractors pay *at least* 50% of the up-front costs of their special tooling and test equipment. The following year the law was changed to require that contractors pay *no more* than 50% of the up-front cost of special tooling and test equipment.

*Analysis.* Selecting the minimum necessary special tooling and test equipment and agreeing on an acceptable payment methodology is a win-win strategy. Requiring all contractors to pay the up-front costs of special tooling and test equipment, amortizing the cost as part of plant-wide overhead, and refusing to indemnify the contractor in the event of program termination is a win-lose strategy that ultimately leads to a lose-lose outcome.

(e) *Action*. Since the mid-1980's it has been popular to require contractors to pay some of the cost of new development programs. This concept, called cost-sharing is simply a way of saying the government does not have enough money to pay for all of the development effort required. Therefore, if a contractor wants to compete, it must agree to pay a substantial portion of the development effort. This practice seems to have reached its peak with the cost-sharing relationship on the Advanced Tactical Fighter where various contractors teams are investing tens of millions of dollars of their own funds (government win-lose). This practice is now being discredited by Congress and the new administration.

*Analysis*. Establishing competition in the design phase and selecting and paying a reasonable price for the most cost effective solution is a win-win strategy. Requiring contractors to fund millions of dollars of development costs with no guaranty of any return, or even recovery of their investment, is clearly a win-lose strategy which ultimately leads to a lose-lose outcome where some contractors will refuse to compete, others will leave the defense market entirely. Those contractors who do stay and win will ultimately charge higher prices to recover the development costs and will propose lower technology and lower risk development efforts.

(f) *Action*. While the actions cited above largely result from efforts by the administration, the Congress has been a willing participant in these and other actions. In some cases Congress has stepped-in to correct a win-lose strategy implemented by the administration. In other instances the Congress has created win-lose strategies of its own. The most obvious current example is the onerous, overzealous new procurement integrity and revolving door legislation. This legislation apparently seeks to prevent any possible wrongdoing by anyone associated with the federal procurement process. It also apparently seeks to remove any possibility of government officials showing favoritism to any contractor in return for some offer of future employment or other benefit.

*Analysis*. The establishment of laws and regulations to identify wrongful acts and to prosecute those who perpetrate them without unduly restricting legitimate and necessary activity is a win-win strategy. Assuming that all who participate in the process are crooks just looking for an opportunity for self-enrichment, erecting overly-restrictive barriers to future employment, and requiring burdensome certifications of legality on the part of thousands of participants in the process is a demeaning win-lose strategy. The inability to attract and retain high-caliber, competent professionals and further increases in the complexity and time required to execute contracts are inevitable lose-lose results of such win-lose behavior.

The six examples cited above are just some of the win-lose type legislative and regulatory activity which has taken place in recent years. There are many other examples which have been implemented and many more that have been seriously proposed and considered but, fortunately, never enacted.

Most of these initiatives have been implemented in isolation, without any real consideration of the combined effect of so many changes, some of which conflict with other ongoing initiatives. The end result is confusion on the part of government and industry alike. The end result is also a significant slowing-down of the contracting process and a reduction in the number of firms who are willing to conduct business with the defense department. These are clearly lose-lose outcomes.

## RECENT EXAMPLES OF WIN-WIN BEHAVIOR

While there are many examples of win-lose activity, there are also some new examples of win-win behavior. To put things in perspective, it is useful to recognize that the win-win principle is the real foundation of the Federal Acquisition Regulation and the Defense Supplement thereto. Over the years, the regulations have been carefully written to balance the needs of both government and industry and to ensure that the rights of both parties are protected. Perhaps that is why it is so disturbing when deviations to the basic philosophy are implemented as new policy or, worse yet, as new law.

These new examples are in accordance with the basic philosophy of the regulations, but they more aggressively pursue the win-win principle. Each of the examples cited below is in its infancy and full results have yet to be seen. These initiatives, which should be evaluated a year or two from now, are: the implementation of the Material Management and Accounting System (MMAS) regulation, the implementation of the Contractor Risk Assessment Guide (CRAG) program, the effect of the Defense Advisory Panel on Government/Industry Relations (DAPGIR), the current emphasis on buying more commercial products using commercial buying practices, and the results of DoD's and defense industry's current efforts in Total Quality Management (TQM). Each of these examples will be briefly discussed below.

(a) *MMAS*. The need for new regulatory coverage for contractor MMAS's was brought to light in 1987 when several DCAA audits determined that certain contractors were misusing automated Material Requirements Planning (MRP) systems to obtain overpayments from the government. Almost immediately the media and the Congress joined the fray. Congress promptly proposed stringent new requirements restricting contractors' use of MRP systems and requiring certification by contractors that their systems were in accordance with all statutory and regulatory requirements. However, before this win-lose legislation was enacted, cooler heads prevailed. A government/industry task force was established to examine the true nature of the problem and to develop appropriate standards for acceptable MMASs.

In the reasonably short period of seven months, the task force had determined the nature of potential abuses which might be caused by contractor MMASs, and had hammered-out mutually acceptable language for improved regulatory coverage. In May of 1989, the new regulation was published. The regulation itself has been widely praised for both its content and for the win-win process by which it was created.

Writing a good regulation, however, does not solve a problem. The real test of the effectiveness of this solution lies in its implementation by contractors and government contract administration officials. If contractors continue to implement effective MRP systems which enhance the efficiency of their operations without creating erroneous charges to government contracts, and if the government obtains equal or better products at lower cost, then this example will truly have a win-win outcome.

(b) *CRAG* The CRAG program was initiated in 1987 as a joint effort of the Office of the DoD Inspector General, the Defense Contract Audit Agency, and the Office of the Under Secretary of Defense for Acquisition. The objective of the program is to improve the effectiveness of DoD oversight of defense contractors and to reduce the duplication of oversight efforts. A DoD task force was formed to identify major areas of financial risk in a contractor's operations. The areas identified were (1) direct labor, (2) indirect costs, (3) material management and accounting systems, (4) estimating systems, and (5) purchasing systems. Once the risk areas were identified, the task force proceeded to develop objectives and characteristics of good contractor internal control systems in each area.

A draft Guide was published and public comments were solicited. Many comments were received and industry was invited to send representatives to Washington to assist in working out necessary wording changes. The final product, which was published in November, 1988 benefited greatly from the joint efforts of the government/industry teams who worked out the final wording of the various CRAG chapters.

Contractor participation in the CRAG program is purely voluntary. If a contractor does participate and demonstrates effective internal control systems in any or all of the risk areas identified in the program, then the contractor can expect to receive less government oversight in those areas. This program is clearly based on the win-win principle and should lead to improved contractor internal controls and reduced government oversight.

(c) *DAPGIR* The 1989 Defense Authorization Act required the formation of a Defense Advisory Panel on Government/Industry Relations. This panel is dealing with some difficult issues, such as debarment and suspension, contractor self governance, and resolution of disputes. Each of the subpanels is searching for win-win solutions to the problems encountered in their respective areas. The DAPGIR report to the Secretary of Defense should be available by the middle of September, 1989. The very formation of a government/industry panel to examine and to recommend solutions to difficult issues of government/industry relations is an encouraging win-win strategy.

(d) *Commercial Products and Commercial Practices* Over the years a number of studies, including the Commission of Government Procurement, the Packard Commission, the Defense Science Board, and others have recommended more aggressive use of products made to commercial, rather than military specifications and the use of simplified procurement practices for commercial items. The basic argument is that the government procurement laws and regulations have become so complex with requirements for certified cost or pricing data; special preferences for small businesses and small, disadvantaged businesses; special accounting and reporting requirements; and many other unique policies and procedures, that many cost-effective products are never offered for sale to the government.

The current effort to buy more commercial products using commercial-style procurement practices is contained in the Defense Management Report to the President, and is supported by a recent Defense

Science Board study report. Proposed legislation has been submitted through OMB to the Congress which would allow the creation of significantly streamlined procedures for the procurement of commercial products. If this effort succeeds, the win-win result will be more products, of perhaps higher quality and lower cost, obtained more quickly through streamlined procedures. Clearly a win for all concerned.

(e) *TQM* The Total Quality Management initiative is a far-reaching initiative intended to create continuous improvement in the quality and productivity of the defense department and of defense contractors. Within DoD, the program is still very much in its infancy. Some contractors have already begun to implement TQM concepts, others are waiting to learn more about TQM and how it affects them.

The win-win principle is at the very heart of TQM. TQM calls for more cooperative, longer-term relationships with one's suppliers; it calls for elimination of non-value-added activity; it calls for greater involvement and cooperation by all the people in the workforce; and it calls for greater focus on customer satisfaction, not just performance to a minimum specification.

TQM requires a change of culture for most organizations which adopt it, including DoD. If this initiative is successful and long-lived, the result will be a giant win-win outcome for government, industry, and the American taxpayer!

## IMPLICATIONS FOR PROCUREMENT REFORM

Procurement reform is certainly a popular topic for the new administration and the new Congress. In the wake of recent and continuing revelations of weaknesses and wrong-doing in the defense procurement community, there are dozens of ideas being espoused as *THE* solution to our procurement woes. Many of these ideas have merit and should be implemented; some do not and should not (but they may be anyway). But few, if any, of the ideas have such universal applicability that they should be implemented across the board on every program and on every contract.

The subject of procurement reform always brings to my mind three major concerns. The first is a concept that I call "Beware the Zealot!" A zealot is a person who is so in love with his cause that he doesn't consider where it applies and where it doesn't. He steadfastly presses for universal application. In so doing, he may become his own worst enemy!

When considering procurement reform it is vitally important to remember that defense procurement covers the widest possible array of goods and services--literally everything from shoestrings to supercarriers and everything in between. It is virtually impossible for any one policy to be universally applicable across such a broad spectrum--even a policy as fundamental to our way of life as full and open competition. There are limits to the applicability of any policy. Our real challenge is not to invent new policies for how we conduct our business--our real challenge is to understand how and when to implement the policies we already have.

My second major concern regarding the topic of procurement reform is that we will attempt to eliminate and prevent, through law, regulation, or company policy, all forms of errant behavior. I believe that if we try to do that, we will strangle ourselves with overly stringent revolving door policies, with overly stringent contractor certification requirements, with overly stringent "insider information" restrictions, etc. We must remember that, while some restrictions are indeed necessary, every form of restriction represents a potential additional cost. Excessive restriction, even in the name of increased procurement integrity, is a win-lose strategy. We would do much better to seek-out and prosecute the occasional example of errant behavior, than to attempt to prevent all forms of abuse from ever happening in the first place.

My third, and greatest, concern regarding procurement reform is whether our reformers will allow themselves to be seduced by the apparent attractiveness of "quick-fix," win-lose strategies. When you are seeking the next headline, pursuing the next vote, or trying to squeeze another million dollars worth of performance out of a tightly constrained budget, win-lose solutions can be overwhelmingly attractive. So the real question is: will our procurement reformers and operating executives choose to pursue short-term, win-lose policies which ultimately and inevitably lead to lose-lose outcomes; or will they steadfastly pursue the win-win principles represented by the basic philosophy of the regulations and enhanced by recent efforts such as the MMAS regulation, the CRAG program, the DAPGIR, the emphasis on commercial products and commercial practices, and the TQM initiative?

The choice is a monumentally important one--the future of defense procurement and the defense industrial base is at stake.

# PRODUCTIVITY

PRODUCTIVITY

"PRODUCTIVITY IMPROVEMENT AND COST EFFECTIVENESS"

(PRICE)

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ABSTRACT

The U. S. Department of Energy, Richland, Washington, consolidated the function of four management and operating contractors into one which is now responsible for operations of all the nuclear facilities, chemical processing, waste management, and support services at the Hanford Site.

During selection of a firm for this four billion dollar contract, the successful firm suggested a cost reduction program to save millions of dollars over the five year period.

This cost savings program was included in the contract as an incentive arrangement to save 50 million dollars the first year of operations. The incentive arrangement rewarded the contractor a million dollars if completely successful but penalized the contractor a million dollars if not successful. The penalty applies until the contractor saved 25 of the 50 million dollars.

This paper provides the incentive structure, principles applied, and the results of the cost saving program which resulted in a savings of over 50 million dollars.

INTRODUCTION

We continually hear that American industry must be more competitive and to accomplish that objective, quality must be improved and costs must be reduced. A slip in quality can effect the standing of a firm in the industry. High costs have the same effect as poor quality, but quicker. While it is important to cut costs in the private sector, it is just as important to cut costs in government to get more program effort for the dollar. The government has developed many different incentive contracts to encourage efficiency and in some cases, contractors have responded by implementing cost savings programs.

A major weakness of some cost savings programs is no long term involvement by top management because of other demanding problems. If that happens, the cost savings program may become just another burden to the first line supervisors and the employees. Both of these groups know the most about their functions and if motivated, will submit good cost savings ideas. If they don't willingly participate in the program, it won't work.

COST SAVINGS PROGRAM

The following is an example of a cost savings program that worked by overcoming these weaknesses and saved the government over 58 million dollars on 800 million dollars of work the first year.

It began during the government's process of selecting a firm for a 4 billion dollar contract for operations of the nuclear facilities at the Department of Energy (DOE), Richland Operations Office, Richland, Washington. One firm suggested a cost reduction program of over 200 million dollars for the five year period. This firm was eventually selected for the contract. The contract was signed with Westinghouse Hanford Company.

During negotiations with Westinghouse, a cost savings program was established to save 50 million dollars the first year of operations which is believed to be the largest cost savings program ever conducted at a DOE site. The program was called "Productivity Improvement and Cost Effectiveness."

The cost savings program worked in my opinion, because success was tied to a million dollar bonus and failure meant paying out a million dollars from profit. This kind of profit or loss catches the attention of senior management and keeps it throughout the year. When senior management stays involved, middle management and first line supervisors stay interested. The employees will respond when they get recognition for their ideas and when they are encouraged to submit cost savings proposals.

The incentive arrangement for the target of 50 million dollar savings in one year is depicted on the following chart. As savings are identified and approved by DOE, they are accumulated during the year. The firm had to save 25 million dollars before they earned any fee. A total savings less that 25 million cost the firm 4 cents on the dollar. After reaching the level of savings of 25 million, the firm earned 4 cents on the dollar up to the maximum of one million dollars. The firm was encouraged to continue the savings program after reaching the 50 million target but was recognized under a separate cost plus award fee arrangement.

The firm submitted cost savings proposals during the year to DOE (see submittal chart) in sufficient detail for a DOE board to review and determine if it should be recommended for approval by the Contracting Officer. The final determination by the Contracting Officer to accept or reject a cost proposal was unilateral and not subject to the disputes clause of the contract. Since most cost savings proposals were estimates of savings, the costs are subject to audit at the end of the period and adjustments to the total savings and resulting fee will be made based on actual costs.

## PRINCIPLES APPLIED AND RESULTS

After the first year of the cost savings program, the principles applied and results are listed below:

Principles Applied:

+Scope of work and costs are controlled by a Work Breakdown System (WBS).
+Cost goals are established within the firm down to smallest organization.
+Status of progress against the goals are reported monthly to management.
+Cost proposals are approved by the firm before submittal to the DOE.
+Cost proposals are recorded in the management reserve of WBS.
+Cost savings may be implemented by the firm without DOE approval.
+DOE cost savings board is established to review cost proposals.
+DOE cost board meets once a month to review new cost proposals.
+Definitions of cost savings must be provided so firm knows the rules.
+Cost proposals should be short but informative and on a standard form.
+Short viewgraph presentations should be made on each cost proposal.
+DOE must review and act upon the cost proposal within two weeks.
+Approved cost savings should be publicized within the firm and DOE.
+Sample audits should be conducted to verify actual savings.

Results:

| | Number | Dollar |
|---|---|---|
| Cost Proposals Submitted: | 321 | 108,827,355 |
| Cost Proposals Approved: | 258 | 58,473,371 |
| Fee Paid | | 1,000,000 |

Examples of Savings:

The initiatives to reduce costs were very innovative, reflecting a wide variety of site activities. For example some of the savings included: reconfiguration of a reactor hydrogen mitigation system for a savings of two million dollars; improved steam plant operations for a savings of one million dollars; floor scarifier in place of a pump to decontaminate floors for a savings of 190 thousand dollars; and changing the packaging for radioactive waste for a savings of 104 thousand dollars.

## COST SAVINGS PROPOSALS

The cost savings submitted by Westinghouse was on a standard form that helped define the amount of information and documentation that was needed by the DOE board to understand and review the proposal. It should be emphasized that Westinghouse management must approve the savings proposal and enter the savings into its management reserve before it is submitted to DOE for review and approval. The following is an outline of the proposal format:

Proposed Project

Existing Practice

Proposed Initiative

Innovation

Existing Baseline Cost

Cost Improvement Estimate

Annualized Net Savings

Schedule/Timing

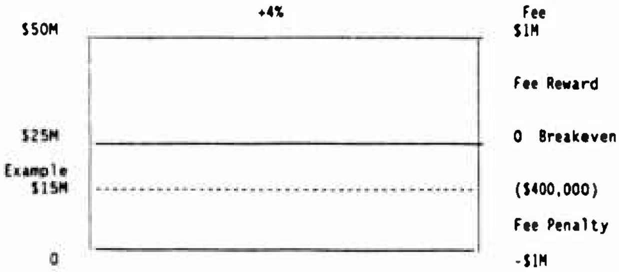
Anticipated Budget/Impact

Implementation Documentation

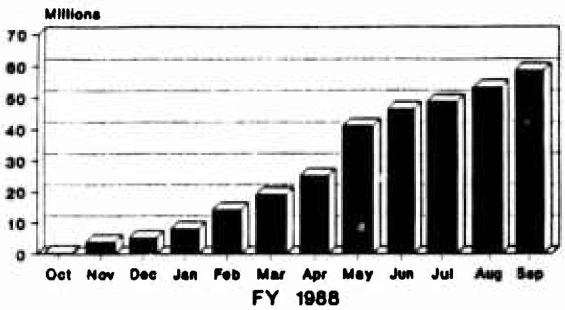
Impact On The Goal

Risk Assessment

While there are many ways to identify cost savings, this type information helps DOE understand and approve cost savings proposals covering many functions such as operations of nuclear reactors, chemical processing, waste management, and support services of computers, guards, trains, busses and warehouses.




Annual Plan Goal: $50 Million
Approved to Date: $58,473,371




Fiscal Year 1988
Series 1

Dollar Savings (in Millions $)

# SMALL PURCHASES PRODUCTIVITY SOLUTIONS FOR THE INTERNAL REVENUE SERVICE

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## ABSTRACT

The procurement function of large and growing organizations needs to continually innovate to find more productive ways to deliver services.

Small purchases requisition processing is one area where volumes are growing and customer service can be improved. Computer technology can be used to improve service, but automation does not guarantee productivity improvements. Simply automating the production of forms used in the procurement process without attention to underlying work flows will do little to advance productivity.

The IRS designed improvements to the small purchases services it provides customers in IRS organizations around the nation and is implementing five automated work management productivity solutions in its Facilities Integrated Management System, FIMS. The key is convenience, the watchword for consumer marketing today. Convenience was built-in to the design by incorporating simplified customer interfaces and automation of procurement specialist workflows. This in turn contributes to data sharing and efficiency which help get the job done right the first time.

A cost-effective distributed processing system with on-line access and a flexible data base provided the technical environment in which the productivity solutions could be successfully put to work in the offices of customers and procurement specialists.

A responsive system was designed by blending functional design features that reflect underlying work flows and the ways users think about information with today's cost-effective technologies.

## INTRODUCTION

The IRS is a large and growing Federal agency. The Facilities Management (FM) Organization provides procurement and other support services vital to the growth and success of the IRS.

In addition to procurement services, the FM organization provides supply, property, building and space management, security, motor pool, support funds tracking, and other similar support services. A decentralized FM organization was established to provide responsive services to decentralized customer organizations. However, current procedures to provide support services require excessive paper flow and filing, manual processing and tracking, and workload management. In addition, standardization is a continuing challenge. Standardization is needed to ensure compliance with regulations and policy, and is essential to operational consistency that allows FM analysts transferred from one office to another to quickly become productive.

Decentralized and geographically distributed customer organizations, combined with high support transaction volumes, provide FM with many challenges. For example, FM processed approximately 200,000 small purchases requisitions in 1988 through a decentralized organizational network that includes staff from the National Office in Washington, DC, 7 Regional Offices, 64 District Offices, and 11 Service Centers. Small purchases include open market procurements with a dollar value of $25,000 or less, all delivery orders, and procurements from other government agencies or the Federal Supply Schedule.

The Facilities Integrated Management System (FIMS) was designed to support not just procurement operations, but all services provided by the FM organization. Basically, a customer request is viewed as the driver for all FM services, whether it is a small purchase requisition or a request for additional space. The "I" in FIMS is intended to reinforce the concept that FIMS is an "integrated" approach to supporting the work processes and management of the entire FM organization.The Facilities' Integrated Management System (FIMS) automates Facilities' functions for the IRS. It serves all levels of Facilities' staff and management as well as Facilities' customers. Objectives for the system are to provide:

- Integrated functions to Facilities' offices which facilitate day-to-day operations by reducing paper flow and duplication of effort, performing certain analyses, maintaining on-line reference materials, and tracking work in progress.

- High quality service to Facilities' customers by streamlining procedures within Facilities and by giving customers direct system access to enter requests and get pertinent status information.

- Management information to field oversight offices which support Facilities program control and planning.

- Support to Facilities' operations for regulations and policies pertaining to standard procedures and data formats.

In a larger sense, FIMS will be used by all IRS organizations, not just Facilities Management. All of the products and services provided by FM are initiated by requests from customer organizations of FM. One of the objectives of the FIMS project is to give all IRS organizations access to FIMS and have them submit their requests using the system. In addition to providing request entry functions, FIMS will allow customers to query the status of their requests, review and approve requests online, certify funds availability, record receipt and acceptance information, record BPA calls, and obtain management reports.

A fundamental objective of the FIMS design effort was that field office staff should define system requirements and approve implementation of the requirements since the system will be used primarily by field offices. To this end, User Groups were established for each of the FIMS application areas. Each User Group consisted of 6 to 12 IRS staff members expert in the application area and representing all geographic organizations and organizational levels. Each User Group had a designated Lead Analyst who was the primary point of contact for the group. The User Groups worked closely with the Project Management Office and system developers to identify and refine system requirements, review system designs and documentation, review and test operational software, and prioritize development efforts.

As another design objective, FIMS emulates the way that people naturally think about information. The manual system employed by the IRS to process requests from initiation to close-out involves various means for creating, changing, duplicating, tracking, authorizing, and transmitting information. This system includes paper documents, multipart forms, photocopies, logs, transmittal slips, internal mail, the postal service, and FAX transmissions. These diverse methods of recording and sharing information are an inherent requirement of the way in which requests are processed, since many people, at different locations, are involved in the process and each person has specific needs for information. FIMS, as an automated system supporting this process, must satisfy the same needs for maintaining and sharing information.

This paper provides an overview of the work management features in FIMS. These features were chosen because they illustrate that FIMS was designed not only to provide basic functionality for producing purchase orders, but also as an operational tool to truly streamline and enhance the entire work process. The work management modules are highlighted in the FIMS Structure Chart (Figure 1) and include five productivity solutions:

- Customer interface that is streamlined, structured, and controlled

- Document handling for automatic updates, assignment, and routing

- Electronic inbox for access controls, organization, and prioritization of work

- Event calendar for managing document activities

- Controls including electronic signature, security, and audit trails.

In order to make these features work, a technical environment had to be established that would put the system to work in the offices of customers and procurement specialists. The technical system design needed to provide:

- Inexpensive and reliable computer resources
- On-demand availability including real-time response and accessible workstations
- Flexibility for new requirements.

Each of these productivity and technical environment solutions are described in the sections that follow.

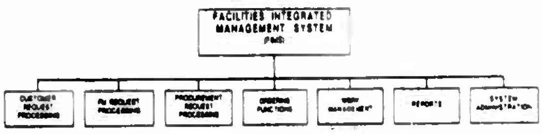


Figure 1. FIMS Functional Structure Chart

## AUTOMATED WORK MANAGEMENT FEATURES

### Customer Interface

FIMS processes requisition transactions by allowing customers to create and modify requests for supplies or services. FIMS allows customers to create a new request using one of two methods: FIMS copies parts of an existing request to a new request and then the user enters and/or changes data as needed; or customers enter all required information for the request. Also, FIMS permits customers to review and modify a request, browse a request, cancel a request, and make inquiries. Consequently, customers do not have to call FM to get results, and equally important FM analyst time can be devoted to processing requests, not changing requests or fielding inquiries.

After the customer has selected the enter new request option, they enter a request category and subcategory which identify the type of supply or service required. A group of data entry screens are then displayed for the customer to enter request information. This uniform, single point of entry for requests reduces confusion that customers experience with different forms and destinations for different types of requests. Further, automated consistency check functions allow users to catch errors or omissions early and avoid data problems that often delay processing.

FIMS displays screens that contain general information common to all requests. This includes the following information for a request as a whole: originator's (requisitioner's) name and organization, date the supply or service is required, request control number (FIMS automatically assigns a request control number to a request after it has been created), and the following general information for each item requested: description, quantity, unit price, suggested sources, accounting code and cost information, and delivery information. The most common information is already filled in. For example, name and address. This eliminates need to re-enter common data for each requisition.

FIMS also displays a specialized group of screens designed to capture information specific to the chosen request category and subcategory. By using these specialized screens, FIMS insures that the customer enters most, if not all, information required for a complete request at the time of request entry. This reduces the need for Facilities specialists to go back to customers for omitted information.

### Document Handling

FIMS supports various types of electronic "documents," including requests for supplies or services, purchase/delivery orders, BPA call orders, imprest fund authorizations, etc. Although these documents are really logically related data elements maintained in data base tables, FIMS users are able to view and manipulate these documents as they would the physical equivalents.

A cardinal rule in FIMS is that only one user at a time is able to update or modify a given document. This user is referred to as the current "assignment" for the document, or the user to whom the document is currently "assigned." This rule precludes a user from making a change to a document that might adversely affect the work of another user. Although only one user at a time can modify a document, other users of the system, according to a predefined set of rules, are able to view or browse the document.

Since documents must be worked on by more than one user, FIMS provides the ability to "route" documents from one user to another. Routing, in effect, changes the current assignment of a document and gives another user update authority for the document. Routing provides an "electronic mail" function that is tailored to the specific needs of the FIMS users. Reliance on the Post Office and internal mail procedures can be reduced. This is a significant benefit, since electronic routing reduces the time to move documents, the overall time to process a request is reduced by days, and in some cases weeks.

Whenever documents are routed from one user to another, the sending user may optionally attach a transmittal slip, or "buck slip," to the document. These transmittal slips are referred to as "notices" in FIMS. Notices provide information to the receiver about why the document was sent to them. Notices may also be sent from one user to another without routing the document itself. These are referred to as "independent notices." This might be done, for example, to obtain additional information from the request initiator.

Documents can be routed in one of two ways. The method described above is used to "manually" route documents. Routing also takes place automatically in certain circumstances. Automatic routing was desigred into FIMS for cases where the system makes a default determination of where documents should be routed.

An example of automatic routing is customer organization review/approval. FIMS maintains site-defined tables that provide the default series of routings that should take place when a request is reviewed and approved within the customer organization; that is, which managers should review and approve requests initiated by each organization. When the initiator of a request indicates that they have completed it, FIMS will display the default series of users to whom the request will automatically be routed. Each reviewer and approver will be provided with the same list when they sign off on the request. The initiator and each reviewer/approver may override the default series of routings if they are inappropriate.

Electronic Inbox

The FIMS inbox is the primary function that users access to organize and accomplish their individual work. As its name implies, the FIMS inbox is where all of the documents that a user is assigned to work on reside. The FIMS inbox provides three basic capabilities:

1. Displays relevant summary information about each document that is assigned to the user;

2. Allows the user to select the particular document(s) that they wish to work on and access the appropriate functional modules; and

3. Provides functions to assist the user in organizing and prioritizing their work.

The inbox is closely tied to the concept of a document's current assignment; all documents assigned to a user are displayed in that user's inbox. Since a document can only be assigned to one user at a time, a document can appear in only one user's inbox at a time. When a document is routed from one user to another, the document will disappear from the sending user's inbox and (immediately) appear in the receiving user's inbox.

From the information displayed in a typical user's inbox screen, the user can readily obtain a great deal of information about their current workload. By using workload management reports FM analysts can better manage, prioritize, and distribute their workload. By looking at the inbox display, the user can:

- Know the number of documents currently assigned to them (and therefore their overall workload);

- Identify those documents that have been newly routed to them, those that are currently in process, those that are put in "Suspense," and those that were just created by the user;

- Identify why a document was routed to them (e.g., routed for processing, review/approval, information, funds certification, etc.);

- Identify the type of document, the document control number, and whether or not there is a routing notice attached to the document;

- Identify the date a document was originated and the originating customer organization.

After the user has selected one or more documents, the user may select a function from a pull-down menu list. The selected documents will be queued to the function for subsequent processing by the user. The user may page back and forth between the selected documents at any time while in the function. When the user is done with the function, the user is returned to the inbox so that other documents may be selected and acted upon. From the inbox the user can choose to browse or modify documents; read the notices attached to documents; route, print, or add notes to documents; or initiate acquisition processing. Most, but not all, FIMS functions are available directly from the inbox.

The inbox also provides functions for managing the user's workload. The user may assign documents to "folders" of their own invention. For example, a user may select several documents and assign them to a folder labeled "Offc Move," "EOFY," or "No Funds." The folder for each document is displayed on the right side of the inbox. The user may also change the inbox status of a document from "In Process" to "In Suspense" and vice versa. (A "New" document is automatically changed to "In Process" the first time the user selects a detailed function, such as Browse, for the document.)

The FIMS rule that allows only the user to whom a document is currently assigned the ability to modify the document poses particular problems when that user is away from the office for an extended period of time. Documents may still be routed to the user, however, that user is not available to process them or route them to another user. To eliminate this problem it is allowable, in certain circumstances, for one user to access another user's inbox. A table of permissions may be established to identify, for a given user, other user's inboxes that may be accessed. Although a user may be "acting" as another user through their inbox, FIMS keeps track of the "actual" user performing the functions, applies the appropriate security permissions throughout processing, and records audit trail information under the actual user's id.

In addition to accessing other users' inboxes, a user may also access the "office" inbox. The office inbox is used to manage documents that are currently in process within the office, but need not be assigned to a particular user. For example, after an order has been issued to a vendor, the order may be placed in the office inbox until such time as items are received or follow-up must be performed. In this way issued orders are easily accessible, but do not clutter individual users' inboxes. Modifications to a document may not be made from the office inbox; the document must be routed to an actual user in order for modifications to be made.

## Event Calendar

FIMS not only allows a user to maintain and manage documents, but through the event calendar helps them manage time as well. FIMS recognizes that documents are not always processed in a sequential manner, that real-world constraints place lead times on processes that can be days or weeks. With the event calendar, a user can manage and monitor those lead times to reduce the overall processing time of certain requests. Event calendar entries are date-triggered reminders that prompt the user on a future date about the processing needs of a FIMS document.

Entries are entered into the event calendar in one of two ways. They may be automatically generated by other processes or manually entered by using the "Add" function from the Event Calendar Summary Screen. If an event is manually entered it can only appear in the initiating user's inbox.

An event is composed of an event number, a trigger date, a user-ID, and the number and type of the document being referenced. The calendar provides a set of functions that allow the user to maintain events. From the Event Calendar Summary the user may Add, Review/Modify, or Delete events.

Once an event's date matches the current date, the entry is removed from the event calendar and placed in the user's inbox. That entry will appear in the inbox as a "New" entry of type "Event." The user may then process the event using the "Read Event" function. The Read Event function allows the user to review, modify, or delete the event from the inbox.

## Controls

The controls within FIMS were designed to improve the reliability and security of work management modules which in turn increases user confidence and realization of the systems productivity benefits.

Rather than requiring users to sign documents on paper, FIMS allows users to sign documents on the system using an "electronic signature." When signing a document, the user accesses a screen specifically for that purpose. The system allows only authorized users to access this screen. To sign a document, the user must enter a special signature password, which is distinct from the password used to login to the system. The printed version of the document will contain the phrase "Electronically signed by:" and the signer's name and title.

FIMS has a flexible yet robust security and validation system. Each user has a set of permission flags associated with the assigned user-ID. These permission flags screen the user for the authority to access sensitive functions and data.

FIMS makes a primary distinction between the customer and the Facilities' user and, based upon this difference, tailors the menus to focus the functionality of the system toward the needs of the user. This allows FIMS to be much more accessible to the customer who only needs to initiate requests while allowing the Facilities' user access to the complete FIMS package.

FIMS also checks a user's authority to perform a function when a user requests access to it. Based upon that check the user will either be allowed or denied access to the requested function. Screening documents by both authority and assignment allows for good security and ensures responsible use of authority while providing the user with all the functionality needed to complete his assigned tasks.

The FIMS audit trail contains detailed information about the activities performed on a request. Each time a significant action takes place, the following information is recorded: document number being acted upon; user-ID that performed the action; date of the action; the action taken; current request status information; and user-ID of the individual currently assigned to the document. The significant actions recorded in the audit trail include: FM Review; FM Approval; routing; cancellation, or any closing action; request consolidation; any change to the request or order status; and splitting requests.

After a request has been routed to Facilities for processing, FIMS keeps track of any changes made to it. Any change made to customer-entered information is recorded as an amendment. These amendments allow users to review any changes made to customer-entered information in the event that a question arises.

## ARCHITECTURE FOR SUCCESS

Even the best application designs will fail if the right technical environment is not established. The FIMS technical environment includes three features critical to success in the IRS:

- Inexpensive and reliable computer resources
- On-demand availability
- Flexibility for new requirements.

### Inexpensive and Reliable Computer Resources

Many organizations have found mainframe-based solutions are not only expensive to develop, but also expensive to operate. The IRS decided early on to install cost-effective minicomputers at Regional and larger District offices for FIMS processing. This not only avoids costly data communications for critical transaction processing but also avoids data center support costs associated with mainframe solutions. UNIX was selected as the operating system to provide portability for converting to even less expensive minicomputers as they are introduced.

Considerable research and analysis was performed by IRS and Viar & Company functional and technical analysts prior to the selection of a hardware and software environment for development and pilot implementation purposes. The hardware and software environment for the service-wide implementation of FIMS will be reviewed at the conclusion of the pilot test.

The FIMS application software has been programmed using the Sybase Relational Data Base Management System (RDBMS) and the "C" programming language. Software has been developed to operate on Pyramid Technology minicomputers running the UNIX System V operating system.

The hardware configuration consists of two Pyramid 9815 minicomputers networked together via Ethernet. One Pyramid serves as the "back-end" processor and controls all access to the data base files. The other serves as the "front-end" processor and controls all user interaction (screen and keyboard activity). For example, whenever a user enters a command to retrieve information from the data base the front-end processor formats the appropriate data base retrieval command, with the key values entered by the user, and sends the command over the Ethernet link to the back-end processor. The back-end processor performs the retrieval and sends the results back to the front-end processor. The front-end processor then formats the results and displays them to the user.

The service-wide configuration is anticipated to be an extension of the pilot site configuration. Upon analysis of the information flows and inter-office support arrangements in place within each region, it was determined that regionally based computer systems are most appropriate for the IRS environment. Each region will have a centralized cluster of minicomputers that will service the entire region (Figure 2). Each cluster will consist of one back-end processor and multiple front-end processors. All end-user access to the computer system will be through the IRS' CDN/PACNET wide-area network. This configuration offers the optimal mix of sizeability, expandability, processor redundancy, maintainability, and cost.

The feasibility of developing Personal Computer (PC) based software was examined during the hardware analysis. It was concluded that the PC would be an appropriate platform for many of the functions in FIMS, but not for all functions (primarily because of the shared nature of the information required and need for immediate access). It was decided that all FIMS functions should be available on the host computer (minicomputer) and developed there first. Once the initial base of FIMS software is fully operational, a subset of FIMS functions will be ported and configured for operation on PCs. Shared data is a key constraint to downsizing the system to PCs.

### On-Demand Availability

Procurement specialists need immediate access to the system to realize the productivity benefits of the system. FIMS processing is interactive, on-line, and available to local users during business hours. FIMS runs under the UNIX operating system which is designed to be interactive. Workstations are provided to each specialist and on-line tie-ins to field customer PCs for data entry can also be supported. System reliability is high and, due to the decentralized approach, preventative maintenance and upgrades can be scheduled around the requirements of local users.

However, access is more than technology. The design has to be friendly as well. FIMS has a full set of menu-driven screens allowing the user to review complete acquisition packages. All information for the acquisition package is maintained on-line, except for attachments that are not

## Regional Centralized Minicomputer Network

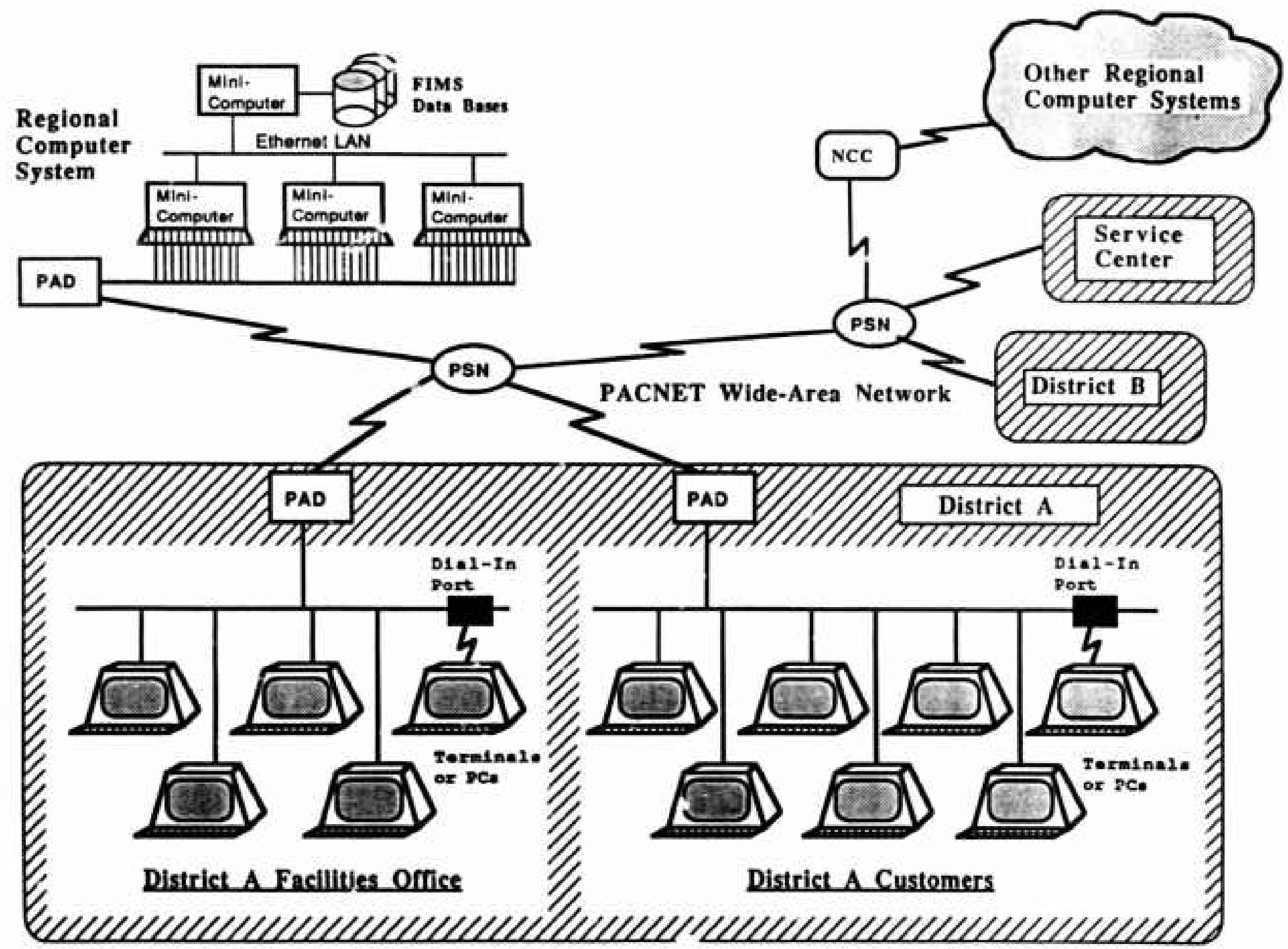


Figure 2

suitable to maintain in an automated format (for example, a signature sample for rubber stamps). When there are special supporting documents, the initiator is able to indicate on the request that these documents exist and are being routed separately, so that they may be checked off when they arrive.

Also, FIMS is a menu-driven system that gives the user the ability to work many segments of the document based around a central summary screen. Using a master detail model, FIMS allows the user to select and modify segments of the acquisition package without paging through other segments. In practice this means that the user can go directly to the information they need with a minimal number of keystrokes.

For example, when reviewing a request, the user is presented with a summary screen for that request. Directly from that point, they may access line item information, justification information, delivery address information, etc.

Flexibility for New Requirements

FIMS was designed with many local options and permits tailoring within pre-set boundaries to local ways of doing business using parameters and table definitions. Intelligent use of default values and site options will tailor productivity solutions to local requirements.

As the FM organization evolves its levels of service, new requirements for automated support are likely. A relational data base management system was selected to provide flexibility for new or changed data requirements without requiring major revisions to the software.

FIMS is built atop a relational data base (Sybase) that has a structured query language (SQL). Ad hoc queries on any data maintained in FIMS are possible. There are a number of standard on-line queries and standard reports available throughout the FIMS application.

FIMS is modular in design, and built for easy expansion. The relational data base allows for relatively easy expansion of data tables and relationships. Currently, request tracking and small purchases applications have been implemented. The ability to expand functionality lies at the heart of the FIMS design.

## CONCLUSIONS AND SUMMARY

Growing organizations often look for decentralized systems to support the productivity requirements of decentralized service organizations and dispersed customer organizations. Improved productivity can be realized in these decentralized service organizations by applying cost-effective, flexible, and accessible technologies to implement work management solutions. Small purchases are increasingly serviced by procurement specialists in the field with few or no automated tools. Today's technology, together with comprehensive application software engineered toward an organization's work flows, can provide complete and proven solutions. Viar & Company has worked closely with the IRS to build productivity solutions into FIMS which blend functional design features with underlying work flows, the ways in which users think about information and today's cost-effective technologies.

# COMMERCIAL PRACTICES

COMMERCIAL PRACTICES

# A TRANSITIONAL METHODOLOGY FOR ACQUISITION OF COMMERCIAL SPACE LAUNCH SERVICES BY THE UNITED STATES GOVERNMENT

R. A. Field, Jr., Martin Marietta Commercial Titan, Inc.

## Abstract

Operating against a backdrop of Presidential policy, new legislation, and emerging Federal agency guidance, Government and industry contracting executives and practitioners are struggling to develop and implement commercial-style methods for Government acquisition of commercial space services. The provision of launch services in particular has served as a pathfinder in this process.

Starting from different cultural perspectives, those involved are seeking to merge the best of commercial practices with the obligations set out in procurement law and regulation. The reconciliation of advantages and imperatives will not be an easy one.

The paper summarizes the recent history and the challenge to all parties, and goes on to describe a strategy for contractual working that can be accomplished in the near term, without the larger shifts in law and regulation which should and shall occur in the long term. The focus is on a methodology that is based in a recognition that a true service (albeit complex and highly technical) is being procured. Hardware and systems adequacy are assured in the pre-award phase. Price reasonableness is assured through an awareness and analysis of market-driven pricing in a new and dynamic world market for commercial space activity. The contract form is based on current Government regulations and requirements, but more judiciously and selectively arrived at. The opportunities for flexibility in the FAR are to be fully explored. Finally, a sequential series of steps for implementation of the approach is posed.

## Background

Considerable interest has been generated in the industry concerning the dichotomy of national policy and legislative emphasis on Government procurement of space launch services from commercial ELV companies as contrasted with the current, and traditional, procedures still being used by Government buying offices (notably within NASA). The recent release of the RFP for Medium Expendable Launch Vehicle (MELV) services by NASA Goddard Space Flight Center has underscored the apparent and persistent belief in NASA that services of this new commercial industry must be acquired without deviating from conventional practices of an earlier era in which space activity was a Government monopoly and the supplier base existed only to serve the Government customer. Attachment 1 hereto presents the key features of this current dilemma.

On May 3, 1989, Representative Bill Nelson, Chairman, Subcommittee on Space Science and Applications, U.S. House of Representatives, expressed his concern along these lines in a letter to Dale Myers, Acting Administrator, NASA, at the urging of the industry COMSTAC committee. While his remarks were directed at the MELV RFP, they reflect a growing sensitivity in Congress to the disparity between legislative intent and procurement action.

## Introduction

In the face of a dynamic and intensely competitive international marketplace of commercial launch operations, where the heavy subsidization of foreign competitors by their governments is a fact of life, pertinent U.S. Government procurement reform is seen as one way to facilitate the growth of the U.S. industry and, indeed, to enable its survival. The key to the maturity of the domestic industry is cost control — and cost reduction. Traditional Government procurement methods do not foster such aims when applied to the acquisition of launch services. This is why the following objective was enunciated in the National Space Policy of January 1988:

> Government space sectors shall ... identify, and eliminate or propose for elimination, applicable portions of United States laws and regulations that unnecessarily impede commercial space sector activities.

The transition in this regard will not occur overnight (the rapid preeminence of foreign competition notwithstanding). However, important first steps <u>within</u> the <u>existing</u> statutory and regulatory framework can be taken without delay while the more massive cultural realignments are set in motion.

### Methodology

The differences between the newly established method of contracting and the conventional Government approach are significant. These are summarized in Attachment 2. However, this is primarily because the Government has traditionally bought hardware for use in its own operations, rather than a turn-key service. The FAR allows for the purchase of services, and even turn-key services, to satisfy many needs. Some of these include:

- Housekeeping operations (food service, custodial service, security services, etc.)
- Transportation services (waste removal, household goods, etc.)
- Operation of research and other facilities ("GOCO" and operating contractor arrangements)
- Construction management (reclamation, base facilities, etc.)
- New technology development ("skunk works" operations)

When taken in this context, space transportation becomes — or can become — yet another total service concept. The following is a review of the primary elements in effecting the transition in concept and the extent to which they serve to overcome existing Government concerns.

### Assurance of Hardware and Systems Adequacy

Government solicitations and contracts for launch services to date have retained a "hands-on" involvement of the Government in hardware production and quality management. This is in spite of the fact that much of the hardware incidental to the provision of the service, as well as the production, delivery, and launch operation regimens, have matured under decades of strict Government sponsorship and oversight. Indeed, certain inspection and launch operations services are still obtained at cost from Government sources to serve commercial purposes, pursuant to statutory entitlement.

Should Federal launch services buyers wish to revalidate the integrity of the services offered commercially, this need can be addressed via the Pre-Award Survey technique discussed at length in FAR Subpart 9.1, as well as in the technical evaluation of the contractor's proposal (FAR Subpart 15.6). While this could (and should) prove to be a rigorous undertaking, the result will be an optimal selection of a competent contractor, and a contract document and performance unburdened by the "double-checking" of Government contract administration.

Such a pre-award method of quality assurance would also serve to ensure the highlighting of anomalies and unforeseen circumstances during performance for management "by exception."

### Assurance of Price Reasonableness

Commercial launch services enterprises were set up to serve in a commercial manner a broad array of world government and private sector customers, at the urging of the U.S. Government. Thus, the pricing of such enterprises has developed along customary commercial lines, i.e., it has been driven by the forces of an international competitive marketplace. The success of the domestic industry in this relatively new and highly competitive market is linked to its ability to blend market intelligence, risk assessment, cost control, and business judgement. Organizational structures and business systems have been streamlined and rendered suitable to this purpose. As a consequence, the elaborate accounting systems utilized for the collection, proposing, certification, reporting, billing, auditing, and defense of cost element data in the Government contracting arena are no longer considered an affordable business practice.

Price reasonableness has become a function of fixed price competitiveness, as opposed to cost make-up justification. Long-term profitability couched in market pricing attractiveness has replaced job cost recoverability.

As a result, the opportunities in the FAR for recognizing the effects of such market forces in arriving at price reasonableness can be exercised relative to exemption from the

conventional requirement for certified cost or pricing data. FAR 15.804-3(g) presents such an opportunity, wherein an individual (or class) exemption from certified data may be made for reasons of market-driven pricing. This provision gives wide latitude to the Contracting Officer for "exceptional cases." The fate of a struggling new U.S. industry would not seem to stretch the meaning of the term unduly.

An additional opportunity to recognize market-driven pricing effects on a related, but separate, financial requirement may be found at FAR 30.201-1(b)(15). This is an exemption from Cost Accounting Standards (CAS) which results directly when the previously discussed exemption from certified cost or pricing data is exercised.

## Form of Contract

It would represent a major leap in Government contracting practice to adopt commercial-style contract paper outright. However, the judicious application and tailoring of existing FAR contract provisions is more readily achievable.

The basic premise would be that "commercial launch services" does indeed represent a form of services contracting, albeit turn-key, complex, highly technological, and of high value. If this fundamental premise is adopted, the following structuring along the lines of FAR guidance is possible.

Contract provisions can be divided into two basic categories. This first category, "Special Provisions," includes those that relate to the specific contracting purpose and tend to be the more operative during administration of the contract. Included in this group are those provisions dealing with the particulars of basic description of what service is being bought, price, method of furnishing the service, time and place of performance, and method of payment (including any financing mechanism). With the exception of payment and financing, these provisions are customarily drafted by the Contracting Officer, acting with wide latitude, so as to serve the unique needs of the procurement in question. They are highly susceptible to negotiation.

Payment is usually considered due upon completion, or upon the rendering of a part of the service which is of severable value. For large and lengthy procurements, such as launch services, the Government recognizes in policy and regulation a need for financing to counter what would otherwise be an untenable burden on industry capital and credit markets. This is often accomplished through progress payments based on costs incurred during performance. For a service industry not attuned to job cost accounting, such as launch services, a method of progress payments based on a percentage or stage of completion is more appropriate. This type of progress payment, sometimes known as "milestone payments," is provided under FAR 32.102(e). It is the method which most closely resembles the "installment" payment methodology adopted in the private sector for launch services.

The second category of contract provisions, "General Provisions," includes those clauses prescribed by the FAR as generally applicable to the major commodity or service class of procurement (i.e., supplies, services, construction, etc.). These "boilerplate" clauses are generally seen by the Government as "mandatory" and "non-negotiable" and cover what are considered broad sovereign rights of the Government in transacting business (e.g., access to facilities and records, contractor accountability, termination, default, etc.) and matters of socio-economic policy (e.g., labor laws, non-discrimination and affirmative action programs, protected sectors of the economy, etc.).

In treating this second category of clauses in launch services contracting, one must be concerned with both accuracy of application and emerging needs for reconsideration and revision to reflect the unique character of the new industry. Attachment 3 hereto contains a list of clauses which have been misapplied to recent launch services procurements, notwithstanding prescriptions in the FAR. Attachment 4 lists those FAR clauses which, although not clearly inapplicable by FAR prescription, are onerous to the commercial space launch contractor and undermine the price competitive imperatives of the industry. While concerns with certain clauses in this latter group may of necessity lead to revised statutes and regulations in the long run, a current method of dealing with many of them is afforded by the FAR at Subpart 1.4, Deviations from the FAR, wherein it is stated:

> The fact that deviation authority is required should not, of itself, deter agencies in their development and testing of new techniques and acquisition methods.

Appropriate contract formation for commercial launch services hinges at this time on the innovative talent of the Contracting Officer in developing appropriate Special Provisions, the accuracy of his selection of pertinent General Provisions, and the willingness of his agency to utilize the deviation mechanism while recommending long-term statutory and regulatory adjustment to the Congress and the FAR Council.

### Summary and Recommendation

A near term realignment of Government buying office practices in the acquisition of commercial launch services along the lines discussed herein is possible – and necessary, if the fostering of a viable, domestic commercial launch industry is desired.. The steps in this process should be as follows (in sequence):

1. A recommendation to adopt this transitional approach should be entertained by the DOT Office of Commercial Space Transportation, the Office of Federal Procurement Policy, and the National Space Council, with issuance of appropriate policy to buying agencies as an objective.

2. A dialogue should be opened between appropriate agency and industry procurement practitioners, with adoption of mutually agreeable practices as an objective.

3. Proposals to the FAR Council and to Congress should be made by industry, and interested OFPP and agency adjuncts, for revised statutes and regulations, with long-term survivability and health of the commercial space launch sector of the national economy as an objective.

### Attachments

1. Current Issues/Concerns Relative to U.S. Government Acquisition of Launch Services

2. Procurement of Space Launch Services, Comparison of Government and Commercial Methods

3. FAR Clauses Used in Commercial Launch Services Procurement that Are Inapplicable by FAR Prescription

4. FAR Clauses Used in Commercial Launch Services Procurement that Are Undesirable/Unacceptable

## Current Issues/Concerns Relative to U.S. Government Acquisition of Launch Services

- Notwithstanding National Space Policy (NSDD, Jan. 5, 1988), Commercial Space Launch Act (as amended), and current administration pronouncements, the approach and contracting practices of Government buying offices have not significantly changed.

- A business-as-usual approach has been seen in:
  - Navy UHF Follow-on (Navy-SPAWAR)
  - GOES (NASA-LeRC)
  - Mars Observer (NASA-LeRC)
  - Medium Expendable Launch Vehicle (NASA-GSFC)

- Launch services procurements are seen as acquisition of a complex, high-tech service using present FAR methods -- but not the result of streamlined, non-developmental item (NDI), or commercial-style initiatives.

- Specific contract provisions tend to be oriented around a program for development, production, and delivery of hardware -- not the furnishing of transportation services:
  - Hardware design review and approval
  - Process system review and approval
  - Production review and approval
  - Property administration, title or security interest, etc.
  - Inappropriate boilerplate (e.g., Jewel Bearings, Buy American Act, Walsh-Healey Public Contracts Act)

- Some clauses are inimical to the streamlined, simplified business structures put in place by commercial launch providers attempting to remain/become cost-competitive in an increasingly severe international market:
  - Cost and pricing data
  - Cost Accounting Standards
  - Inspection, quality assurance
  - Small and small disadvantaged business subcontracting
  - Labor surplus area subcontracting
  - Various requirements for flow down of requirements to subcontractors (who may already be in-place suppliers with relationships based on commercial agreements)

- Some clauses do not even reflect current statutory/regulatory developments:
  - Safety and health
  - Insurance

Attachment 2

**Procurement of Space Launch Services**
**Comparison of Government and Commercial Methods**

| Aspect of Procurement | Conventional Government Approach | Commercial Approach |
|---|---|---|
| Object of procurement | Unique hardware, for assembly and use by the customer. Incidental services. | Standard turn-key service, for transporation of "goods" (spacecraft). |
| Contract payment type | Cost-reimbursement or fixed-price with cost control incentive (customer assumes or shares cost risk). Capital investment and all costs of performance tied to stand-alone contract. | Firm fixed-price (total cost risk assusmed by contractor). Capital investment amortized over all sales. Costs of performance benefit from sharing of resources in production line. |
| Competition | Highly structured, as prescribed by federal regulations (FAR). Some non-competitive, when formally justified. Selection on price, technical, and other factors (including compliance with rules of the competition). Drives cost recovery in pricing and competitive gamesmanship. | Relatively informal. Simple procedures. Both competitive and non-competitive, according to preferences of customer. Selection based on price and availability. Drives competitive pricing and customer service. |
| Contract Form | Lengthy and complex, pursuant to statutory and regulatory requirements. Contains mandatory, but unrelated, provisions. Requires extensive administration. | Relatively simple. Contains only what is essential. Administration is simplified. |
| Performance | Customer has extensive "hands-on" involvement and unilateral change authority. Start-stop tendencies. | Contractor has full responsibility for efficient operation, cost control, and timely delivery of service. |
| Liability | Statutory insurance requirements for launch site and third party coverage. Customer assumes preponderance of other liability. | Statutory insurance requirements for launch site and third party coverage. Balance of liability shared by the parties. |

**FAR Clauses**
**Used in Commercial Launch Services Procurement**
**that are Inapplicable by FAR Prescription**

| Clause | | Reason |
|---|---|---|
| 52.208-1 | Required sources for jewel bearings and related items | For supply contracts only |
| 52.210-5 | New material | For supply contracts and service contracts where incidental parts are furnished |
| 52.212-9 | Variation in quantity | For supply contracts and service contracts where supplies are furnished |
| 52.215-26 | Integrity of unit prices | Service contracts where supplies are not required to be furnished are excluded from application |
| 52.215-31 | Waiver of facilities capital cost of money | Governing FAR subpart applies only to procurements involving negotiations based on cost analysis (and therefore on proposed cost elements) |
| 52.215-32 | Certification of commercial pricing | For supply contracts only |
| 52.217-7 | Option for increased quantity - separately priced line item | Service contracts are excluded from application |
| 52.219-9 | Small business and small disadvantaged business subcontracting plan | Procurement must offer (new) "subcontracting possibilities". Does not fit commercial profile of preexisting suppliers. |
| 52.220-4 | Labor surplus area subcontracting program | (See 52.219-9) |
| 52.220-20 | Walsh-Healey Public Contracts Act | For supply contracts only |
| 52.225-3 | Buy American Act-supplies | For supply contracts and service contracts where incidental parts are furnished |
| 52.225-11 | Certain communist areas | For contracts where acceptance will take place outside U.S. |
| 52.227-10 | Filing of patent applications - classified subject matter | Such action not reasonably expected to occur in commercial launch services |

**FAR Clauses**
**Used in Commercial Launch Services Procurement**
**that are Inapplicable by FAR Prescription**

Attachment 3

| Clause | | Reason |
|---|---|---|
| 52.227-12 | Patent rights-retention by the contractor (long form) | Patentable items not reasonably expected to arise in commercial launch services |
| 52.229-5 | Taxes-contracts performed in U.S. possessions or Puerto Rico | No foreseeable performance will take place in these geographic locations |
| 52.246-2 | Inspection of supplies - fixed price | For supply contracts and service contracts where supplies are furnished |
| 52.246-23 | Limitation of liability | For contracts providing for the delivery of items |
| 52.246-24 | Limitation of liability - high value items | (See 52.246-23) |
| 252.208-7000 | Required sources for miniature and instrument ball bearings | For contracts providing for the delivery of end items |
| 252.208-7001 | Required sources for precision components for mechanical time devices | (See 252.208-7000) |
| 252.208-7002 | Required sources for high-purity silicon | (See 252.208-7000) |
| 252.208-7003 | Required sources for high-carbon ferrochrome (HCF) | (See 252.208-7000) |
| 252.208-7005 | Required sources for forging and welded shipboard anchor chain items used for military application for combat and direct combat support items | (See 252.208-7000) |
| 252.217-7226 | Required source for jewel bearings and related items | (See 52.208-1) |
| 252.225-7002 | Qualifying country sources as subcontractors | Dependent on application of 252.225-7006 (see) |
| 252.225-7006 | Buy American Act, Trade Agreements Act, and the Balance of Payments Program | (See 52.225-3) |

Attachment 3

**FAR Clauses**
**Used in Commercial Launch Services Procurement**
**that are Inapplicable by FAR Prescription**

| Clause | | Reason |
|---|---|---|
| 252.225-7008 | Duty-free ent , - qualifying country end products and supplies | For supply contracts and service contracts where supplies are furnished |
| 252.225-7011 | Preference for domestic specialty metals (major programs) | For contracts where an article is delivered |
| 252.231-7001 | Penalties for unallowable costs | For cost reimbursement contracts |
| 252.235-7002 | Recovery of nonrecurring costs on commercial sales | Irrelevant to non-developmental commercial services contracts |

Attachment 4

# FAR Clauses
## Used in Commercial Launch Services Procurement that are Undesirable/Unacceptable

| Clause | | Benefit to Government of Removal/Modification | Impact on Contractor of Acceptance |
|---|---|---|---|
| 52.212 '3 | Stop-work order | Obliges better requirements definition and budgetary planning. Ensures uninterrupted service and avoids cost associated with interruption. (Note: use of clause is discretionary.) | Disrupts production line(s). Complicates relations with shared-ride customers. Low volume precludes diversion to other customers. |
| 52.215-22 | Price reduction for defective cost or pricing data | Reduces administrative costs. Allows for lower acquisition cost, through reliance on market-driven pricing rather than cost justification. | Necessity to establish costly support systems and staffing for job cost management. Defeats commercial streamlining for competitiveness. |
| 52.215-23 | Price reduction for defective cost or pricing data-modifications | (See 52.215-22) | (See 52.215-22) |
| 52.215-24 | Subcontractor cost or pricing data | (See 52.215-22) | Disturbs existing commercial agreements with preferred suppliers (also see 52.215-22) |
| 52.215-25 | Subcontractor cost or pricing data-modifications | (See 52.215-22) | (See 52.215-24) |
| 52.216-25 | Contract definitization | More flexible language would permit greater flexibility in using letter contracts where appropriate | Subjects Contractor to unilateral definitization of contract by Contracting Officer in the event of negotiation impasse |
| 52.217-2 | Cancellation of items | (See 52.215-22) | Requires cost-based substantiation of cancellation charges (see 52.215-24) |
| 52.222-28 | Equal opportunity pre-award clearance of subcontracts | Reduces administrative costs | Dependent on application of 52.244-1 (see) |
| 52.228-5 | Insurance - work on a Government installation | Ensure consistency with prevailing statutory authority given to DOT for determining required coverage | Produces conflict with obligations imposed under DOT order |
| 52.230-3 | Cost accounting standards | (See 52.215-22) | (See 52.215 .2) |
| 52.230-4 | Administration of cost accounting standards | (See 52.215-22) | (See 52.215-22) |

## FAR Clauses
## Used in Commercial Launch Services Procurement that are Undesirable/Unacceptable

Attachment 4

| Clause | | Benefit to Government of Removal/Modification | Impact on Contractor of Acceptance |
|---|---|---|---|
| 52.230-5 | Disclosure and consistency of cost accounting practices | (See 52.215-22) | (See 52.215-22) |
| 52.232-16 | Progress payments | (See 52.215-22) | (See 52.215-22) |
| 52.244-1 | Subcontracts (fixed price contracts) | Reduces administrative costs | Requires high degree of accountability and justification to support relatively isolated and low dollar value procurements related to contract changes |
| 52 246-4 | Inspection of services - fixed price | Reduces administrative costs. Allows for lower acquisition cost through a "hands-off" approach to standard products and services. | Necessity to establish costly support systems and staffing for redundant oversight of performance. Defeats streamlining for competitiveness. |
| 52.246-11 | Higher level contract quality requirement (Government specification) | Reduces administrative costs | (See 52.246-4) |
| 52.249-2 | Termination for convenience of the Government (fixed price) | Reduces administrative costs with substitution of commercial-style schedule of cancellation charges. Liability is known in advance and fixed. No necessity exists for Government to take unwanted hardware/material. | Necessity to establish costly support systems and staffing to address closeout factors including: (i) settlement of subcontractor claims by Government, (ii) transfer of title to property, (iii) certification of termination claim, (iv) Government determination of net profit on work done, (v) costs-oriented settlement, with applicability of Federal cost principles, (vi) unilateral right of Government to determine settlement, (vii) repayment of excess amounts determined by Government to have been paid |
| 52.249-8 | Default (fixed-price supply and service) | None | Requires open-ended liability for Government reprocurement costs |

**FAR Clauses** Attachment 4

**Used in Commercial Launch Services Procurement that are Undesirable/Unacceptable**

| Clause | | Benefit to Government of Removal/Modification | Impact on Contractor of Acceptance |
|---|---|---|---|
| 252.215-7000 | Aggregate pricing adjustment | Dependent on application of 52.215-23/24/25 (see) | Dependent on application of 52.215-23/24/25 (see) |
| 252.231-7000 | Supplemental cost principles | (See 52.215-22) | Requires appliction of DoD cost principles (as well as general FAR principles) to determine allowability of costs (See also 52.215-22) |
| 252.233-7000 | Certification of requests for adjustment or relief exceeding $100,000 | Reduces administrative costs. Allows for lower acquisition cost. | (See 52.215-22) |
| 18-52.204-70 | Report on NASA subcontracts | None | Contemplates undefined source selection and subcontracting. Commercial sources are usually already identified and under contract |
| 18.52.223-70 | Safety and health | Prevent intra-Governmental conflict in subject requirements | Does not reflect preexisting programs, such as launch site agreement and associated authorities, and produces conflict in satisfying subject requirements |
| 18-52.245-73 | Financial reporting of Government-owned/ contractor-held property | Reduces administrative costs | Paragraph (a) of clause normally excludes payload property from requirements. Would require establishment of special property accountability procedures. Potential of increased liability if payload is considered "held" by contractor, as opposed to "mated" to launch vehicle in the course of service |

# COMMERCIAL PRACTICES FOR DEFENSE ACQUISITION

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## ABSTRACT

"Instead of concentrating on the things that are being done wrong and trying to fix them with more laws, more regulations, more inspectors, DOD should concentrate on those things that are done right and use them as models." (Packard Commission Report, p.42.)

This paper briefly summarizes the efforts of the first group of military Research Fellows at the Defense Systems Management College. Commercial Practice was selected as the research topic area to capitalize on: 1) the apparent interest in having the Department of Defense (DOD) "do business like business"; 2) contacts and knowledge gained at Harvard's executive development program; and 3) the strong, functionally diverse acquisition backgrounds of the authors.

Commercial management practices were investigated for clearly successful major programs which can be implemented within the authority of the Secretary of Defense. The commercial practices are: 1) program stability (aspects other than funding which remains largely in the domain of Congress), 2) quality sourcing, 3) supplier relationships, and 4) regulation. Our investigation drew heavily on our interviews with industry representatives from which we developed seven commercial case studies of successful, major, new product and capital plant/equipment programs.

In our findings, specific techniques for managing successful major commercial programs are identified and explained. These findings and suggested improvements in DOD acquisition are related to the target practices we investigated in Figure 1.

**Figure 1. Relationship of Study Focus to Findings and Recommendations**

| STUDY FOCUS | FINDINGS | RECOMMENDATIONS |
|---|---|---|
| Program stability | • Top management involvement<br>• Organization commitment<br>• Line acquisition mgmt authority<br>• Schedule Primacy | - Prioritize among C,S,P objs at MS II<br>- Subordinate PPBS to baseline at MS II<br>- Reduce # and level of decision MSs<br>- Empower PM/PEO/SAE<br>- Improve acq'n profs' career mgmt system<br>- Give personnel control to PM/PEO |
| Quality sourcing | • Selection basis quality & price | - Provide on-line Kr performance file<br>- Use variable specs |
| Supplier relationship | • Cooperation vs competition | - Stop subcontract competition advocacy |
| Regulation | • Uniform admin systems | - Use Kr CAS<br>- Apply reporting rqmts to company, not to contract |

## INTRODUCTION

Using commercial business practices, or "doing business like business," has been a recurring theme in the defense reform debate. The 1972 Commission on Government Procurement called for the "businesslike" operation of federal procurement. The 1984 Grace Commission sought to apply "private sector management tenets" across the entire federal government. More recently, the Packard Commission and the 1986 Defense Science Board (DSB) noted the potential advantages of adopting commercial practices in the Department of Defense.

Despite the potential advantages that commercial practices offer, however, DOD has yet to implement them on a widespread basis. The exhibit below shows basic reasons for delay.

## INSTITUTIONAL IMPEDIMENTS TO THE GOVERNMENT USING COMMERCIAL PRACTICES

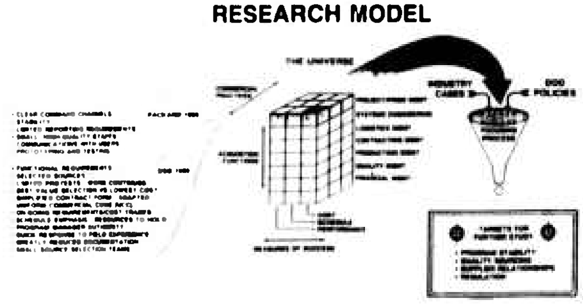
—Confusion over specifically what they are
—Sheer size of public sector
—Inherent differences between the public and private sector

| PRIVATE SECTOR | PUBLIC SECTOR |
|---|---|
| Single Constituency: "Shareholders" | Multiple Constituencies: "Stakeholders" |
| Singular Focus: "Efficiency" | Mixed Focus: "Efficiency" & "Equity" |
| Clear Measure of Success: "Bottom Line" | No Clear Measure of Success. |

Some say these differences between the public and private sectors are so profound that government can never 'do business like business'. Others, notably the Packard Commission and the DSB, recognize these differences but feel DOD can still benefit from lessons of the commercial sector. Believing this, we investigated commercial practices for opportunities to improve the acquisition process in DOD.

Principal methods of investigation were literature review and personal interviews. The research model we developed as the framework for our investigations is shown in Figure 2 below.

### RESEARCH MODEL



FINDINGS

We observed little in the commercial acquisition environment new or different from what has always been known as good management practice. Many of the good ideas proposed by the Packard Commission and the Defense Science Board simply must overcome tremendous organizational inertia. As a direct result, many good business practices, though employed somewhere in DOD, are not in wide usage.

Finding 1. Active involvement of top corporate managers is essential to program success.

Successful, major, systems programs within the commercial acquisition environment are the product of unequivocal top management approval and support. In projects reflecting the strategic emphasis of the company there was clear linkage to organization business strategy and direct involvement of the Chief Executive Officer (CEO).

Top management leads (e.g. promotes within) these selected programs by: 1) communicating the vision, 2) reviewing programs often, and 3) solving problems beyond the control of lower-line managers. Once a decision is made to enter engineering development, the CEO commits to seeing it through.

Finding 2. The commitment to program success crosses organization lines.

In each company we visited there was real organization commitment to the success of major programs. The commercial marketplace severely penalizes companies which do not bring new products on line once major resources have been committed. The functional staffs, operational and program managers exhibited shared goals and direction. Managers of functional departments and staff directorates were responsible for providing resources (the right people and technology) and assisting the program/project manager (PM) to solve problems. They were not involved with program oversight and direction.

Finding 3. Program managers are afforded significant authority and resource control, and are held personally accountable.

Program management authority was assigned to a clearly-visible acquisition line manager and this authority was not shared with functional managers. Acquisition line managers generally are 'Captains of their Ships,' held responsible and accountable for the success of the project but given the authority to make timely decisions and control critical resources (especially participating personnel).

Successful commercial programs are also dependent on focused decision-making up the line; PMs of major systems have and use direct access to top management to keep the CEO, or surrogate, informed and to resolve problems beyond the capability of the PM. Senior functional officers (e.g. VPs of marketing, engineering, manufacturing, etc.) are charged with providing support to line management but not direction of lower-line program management. They provide experienced, professional personnel to give the PM every opportunity to get it done right the first time.

Finding 4. Schedule is first among cost/schedule and performance.

Without exception, we found that schedule was the driving motivation, thus the number one priority in the commercial acquisition environment. This practice is primarily market driven due to implications of late entry on long-term market share and the need to recover investment and overhead costs quickly.

Performance features were the next priority. Sufficient performance (mission capability, supportability, life cycle costs and unit costs, etc) is ensured. But stretch goals were used, with contingency developments to facilitate trade-offs should the schedule be jeopardized or development costs become excessive. Preplanned product improvement, or evolutionary development, was the standard approach to pick up desired technology or features not available at planned schedule cutoff points.

Funding is the business tool to achieve on-time program completion. In all cases a 10 per cent buffer was provided to the PM or his first-line general manager to use to keep on schedule and to solve unexpected technical problems.

Finding 5. Price is but one element in the purchase decision.

Ownership cost and dependable quality were dominant variables in commercial buying decisions. Purchase price would be traded off for desirable features, uniformity and dependability in required products. Firms tended to have a strong technical (engineering) background in the purchase department.

Companies prefer to deal with a few suppliers. They do not abandon competition but, instead recognize its limits. Practices such as Just-in-Time (JIT) and Material Requirements Planning (MRP) depend on reliable deliveries of uniform quality from suppliers. Quality is becoming a total company commitment with access and input to data base information being made available to more organizations in the company. Firms are developing systems to factor past performance into their source selection decisions and are communicating these systems to their suppliers.

Finding 6. Companies are adopting more cooperative relationships with their suppliers.

There is a clear trend for companies to adopt cooperative relationships with suppliers, away from the traditional, competitive way of doing business. This new relationship goes by many names (partnering, strategic alliances, co-makers, value-added partnerships, etc.), but the central elements are common: long-term arrangements with a small number of high quality suppliers; relationships characterized by mutual dependence and open communications.

We found that every company visited was using partnering to some degree. Commercial companies do not use sole-source on a wholesale basis. Rather, they apply business judgment to each situation, forming partnerships with a few suppliers for most items, but reserve sole-source arrangements for items of particular importance. But DOD contractors stop short of effective partnering with suppliers. They seem to do so because of the perception that DOD desires full and open competition in subcontracting.

Finding 7. Companies adopt uniform administrative systems.

In several instances we visited firms which did defense and commercial business. As a general practice, these companies segregated their business units so that commercial and defense business was not collocated or co-managed. In those cases where the firm was producing a defense item and a commercial item on the same floor, they would adopt the defense approach to sourcing, inspection and quality control for all items on the floor. The cost of managing two systems was deemed to be too expensive and confusing to the workforce.

We found that relaxing a standard for a given contract was in many ways ineffective. Generally, if the company has other defense contracts, it imposes the defense standard requirement on itself so that it would not lose certification of its process. This has a significant policy implication because we may consider relaxing certain requirements for a good contractor on a specific contract expecting cost savings to be applied to the contract. But this may not be the case if the contractor has other government business which will not be affected by the waiver, or if he wishes to compete for other defense business for which the waiver may not be granted.

SUGGESTED IMPROVEMENTS

We do not believe that defense acquisition is beset with rampant fraud, waste and abuse. Rather, it is a huge, bureaucratic system operating in an environment of conflicting objectives and expectations and thus, unacceptably inefficient. Also, we reject the naive perspective that all answers can be found in private industry because problems can also be found in many failed products. In looking at how industry acquires capital and develops new products, we have focused on successful programs, identified contributing management practices and recommended adoption of these practices for use in defense acquisition.

Improvement 1. Establish at MS II (MS III for NDI programs) the relative priorities of program cost, schedule and performance in the baselines with maneuver room for practical trade-offs.

At MSII, the baselined schedule should be as short as practically achievable via prudent cost/performance trade-offs made during the program planning process. Stretch objectives should be incorporated if technology permits, or reserved for evolutionary upgrade if technological availability threatens the schedule. The PM should have authority to use the best functional support available, and his judgment, to assess relative costs and benefits of performance trades and to make timely trade-off decisions. A cost buffer of 10 percent should be made available to PMs/PEOs, without need to revisit the PPBS or program baselining process, to maintain schedule and solve technical problems.

Improvement 2. Subordinate PPBS funding decisions to DAB or SSARC approved program baselines at MS II and beyond.

Implementation of this improvement would entail:

1) phasing in of Defense Enterprise Program-like (DEP) programs (major and non-major) with milestone-authorized stable funding, and

2) subordination of future PPBS decision-making to program baseline decisions at MS II and III (too often budgetary cuts are applied 'across the board' as though no priorities exist).

Key to this implementation is disciplined decision-making, based on realistic planning and programming, and institutional follow-through based on commitment to, and communication of, strategic priorities.

Improvement 3. Reduce the number and level of program decision milestones.

Implementation of this improvement within DOD would entail limiting DAB oversight and decision to MS II only, for DOD major programs (SSARC II only for component programs); accordingly reduce the preceding and succeeding milestones one level; and delegating all other milestone decisions to the PEO in coordination with the 'user' (surrogate user).

Improvement 4. Empower acquisition line managers (i.e.,PM, PEO, SAE and DAE) to make program decisions, within approved program baseline constraints, without interference from functional staff advocates.

Following program approval, as discussed in the previous improvement, to enter full-scale development, the PM and PEO would be empowered to use the best expertise available to solve problems and perform trade-offs as necessary to complete the program within baseline constraints and without independent oversight or direction from functional staff managers. The Service Acquisition Executive (SAE) or Defense Acquisition Executive (DAE) should be kept informed of progress and problems, directly by the PM/PEO, on a quarterly basis. The SAE or DAE would then be the link to the Defense Resources Board (DRB) and the Congress should the program baseline need to be altered. Should 'fact-of-life' strategic events occur, such as a major force reduction, the DAE and DAB should act to implement applicable changes to the baselines of impacted programs.

Implementation of this improvement would entail ensuring that baseline objectives were sufficiently prioritized so that acquisition line managers (PM, PEO, SAE and DAE) have flexibility to solve technical problems during execution.

Improvement 5. Strengthen the professional functional support to program managers; reduce dependence on staff functional oversight of programs; change the focus of functional staff managers to acquisition professional development.

The thrust of this improvement is to implement, within DOD, a system whereby top functional staffs are primarily focused on creating and managing a system to educate, train and govern the careers of acquisition professionals. Such a system would provide PMs and PEOs the power to make essential personnel and program decisions and the functional expertise to plan, organize and execute programs right the first time.

Improvement 6. Ensure that matrixed, functional, program support personnel are dedicated to programs through organizational alignment and incentives.

To the maximum degree possible, matrixed personnel should work full-time for, and be rated by, the PM. This improvement is intended to augment improvement number 5 by extending implementation to the acquisition and materiel commands of the Services where, in many cases the functional acquisition specialists and PMs/PEOs have different chains of command. The thrust of this improvement is to provide PMs and PEOs the functional expertise they require, and deserve (dependent on program priority) to plan and execute the program right the first time. We must get away from the climate in which senior military and civilian leadership tolerates, even encourages, PMs to compete with each other for adequate resources, and accepts the divided loyalty engendered in our special advocacy system. These senior leaders should stop acting as 'judges' of programs and actively manage the acquisition system.

Improvement 7. Develop an on-line contractor performance history file which is available to the contracting officer (source selection official in systems programs).

This improvement is primarily directed at procurement of non-system equipment and services which usually do not rate a source-selection-evaluation process.

The first step in using quality information in making source selections is to make it available to the contracting officer. Implementation of this improvement should be phased. First, elements of the file need to be established. They should include indices for price, delivery, and reported quality problems. Second, the ability to input and access the files throughout DOD must be established. A partial net will not be sufficient, since it will fail to provide the objective information needed to eventually make source selections. Third, once the network is functioning, quality factors can be established to adjust bid prices to reflect the cost of schedule or other problems.

Improvement 8. Establish a variable specification method of contract source selection for non-system procurement.

The current method of establishing a minimum specification which, if satisfied, permits the selection to be made based on price, should be selectively replaced by a method through which target performance specifications are set. Variations around this target will be evaluated using a pre-established and published cost/performance trade-off formula. For example, life-cycle cost elements of performance/quality (i.e., reliability, maintainability, etc.) could be quantifiably related to adjustments to the price basis for award.

Such a method would provide incentives for contractors who have better ways of meeting requirements to be selected over contractors who barely meet the specification at the lowest cost.

Improvement 9. Adopt, communicate, and enforce a policy of complete neutrality with regard to subcontract competition, including a cessation of data gathering.

Because competition connotes fairness and equity in the expenditure of government funds, it will likely be the preferred method of government procurement for years to come. The need for equity is much less compelling at the subcontractor level, however, and the degree of competition or cooperation with suppliers is a purely business decision. In many, or perhaps most, cases, prudent business judgment will warrant the use of some form of competition but, in others, the benefits of improved quality, or reduced total costs will call for a sole-source, cooperative arrangement. DOD should not restrict its contractors from using the best business practice; then, as always, hold them strictly accountable for ultimate results. Only with this flexibility can the defense industry be expected to fully implement new ways of doing business like TQM.

Improvement 10. Use the contractor's cost accounting system and eliminate any duplicate reporting methods.

The intent of the Cost Schedule and Control System (CSCS) was to use contractor provided data to monitor the performance under the contract. In intent and concept, it is not significantly different from the systems described as being in place to monitor commercial capital improvement projects or new product introductions. Unfortunately, the CSCS system has become a source of contention between the government and the contractor in its application.

Taken from the perspective of the commercial program manager, the CSCS system provides too much information. What is truly needed is a system which provides top-level overview of cost and schedule progress and which is timely (i.e., actual, vice massaged data) and accessible on a daily basis. The detailed back-up should be available on an 'as needed' (query/response) basis to investigate any problems highlighted in the top-level document.

Improvement 11. Waivers of policy and reporting requirements should be granted for an entire commercial activity for an extended period of time, not on a contract-by-contract basis.

Commercial entities need and employ consistent standards for administering activities. Policies that encourage a perception of uniqueners in defense procurement are often counterproductive because commercial business administrative systems have difficulty adapting to them. It is felt to be just 'too expensive' to operate parallel systems which must meet different policy or reporting requirements.

Policy or reporting changes need to be company-wide, and for extended periods, if any positive results can be expected.

INHIBITORS

Many of our suggested improvements are quite similar to those of previous studies; it is, therefore, reasonable to ask why they have not already been implemented? We realize that overcoming institutional inertia is a major impediment to successful application of good ideas across a huge bureaucracy.

The Department recently underwent a major acquisition reorganization in response to the Packard Commission recommendations. We, therefore, do not attempt to deal with organization issues but instead concentrate on people and process management issues. Nor do we propose any manpower adjustments. We do strongly sense that most acquisitions professionals can be much more effective and the acquisition process much more efficient if these commercial management techniques are institutionalized in DOD.

CONCLUSIONS

Our opportunity to research systems acquisition and purchasing management has been unique; over seven months to assess how private industry manages systems programs and purchasing. The field of study we chose is huge. The allegorical analogy is that of a seven year old child given $10 to spend at a 'Toys-R-Us' toy store on anything he wishes. In our case, there was so much to investigate. Though our main resource, time, seemed substantial at the start, it ran out long before we could satisfy all our research desires.

We approached this research to find good ideas and techniques; not to find more problems. The Press, GAO, and Congress have done enough of that. Instead, we sought to build on our experience in program offices, buying commands and at Harvard Business School last fall to improve the defense acquisition process. Our focus on commercial practices permitted various topics to be investigated in detail and scoped the potential for further research in the field. The improvements suggested herein can do much to put defense acquisition in the forefront of effective and efficient business management.

# INCENTIVES

# CAN AWARD FEE CONTRACTS SUBSTANTIALLY IMPROVE THE ACQUISITION PROCESS

## A SYNOPSIS OF A THREE YEAR RESEARCH PROJECT SUPPORTED BY THE DOD AND NASA

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Professor, University of Notre Dame

### ABSTRACT

The Award Fee contract, although suffering an image problem in current years, in many ways offers solutions to many of the problems confronting acquisition. Since its modern birth somewhere in the early sixties, its breadth and scope of utilization has grown to where it is currently being used for almost every type of procurement, even though its overall use in measurements of total dollars is modest. Is it the panacea promised by its proponents over the years? Or is it a "giveaway," as many of its congressional critics have vehemently suggested of late? Hopefully, this paper provides some answers. It is a summary of a mammoth 247-page summary report of a four-year research program sponsored by the Department of Defense and NASA. The paper addresses:

1. The history of the use of the Award Fee contract
2. The design and use of the Award Fee contract over the years
3. The major concerns about the Award Fee contract
4. The fundamental questions asked about the Award Fee usage
5. The hypotheses about the effectiveness of the Award Fee
6. Conclusions on key concerns
7. Conclusions on fundamental questions
8. Conclusions on hypotheses
9. The "Golden Rules"
10. Appendix: Strengths and weaknesses

Overall, the Award Fee is a sound, effective management system. Its effectiveness is primarily derived from its organizational penetration, its ability to get actual contractor attention thru hooking personal instead of organizational goals, the teamwork that it fosters, the flexibility inherent in the process, and finally, the discipline and structure that it encourages and demands. But it is not, as with most things in life, a panacea. Used effectively, it has much to offer that is currently not available with other contracting methods.

### SYNOPSIS

I have been involved with acquisition since 1956. The last ten years, sponsored thru grants, I have been engrossed in the analysis of the process. The focus has been primarily on the "management umbrella." Specifically, I have been studying the acquisition process vis-a-vis the incentive type procurement arrangements. From 1983 to about 1987, I focused on the Award Fee as a management process. It think it's a methodology still waiting to be discovered. For a wide range of programs, it is admirably well-suited and preferred, in my opinion, to available options. Its use has been relatively minor since its inception. I think it should be used more. In this paper, I explore how I arrived at this conclusion. Please see the complete study before you decide for yourself.

### INTRODUCTION

In an American Management Association Meeting in December, 1963, Gordon Tyler, then Chief of Procurement of NASA's Goddard Space Center, expressed dissatisfaction with the traditional multiple incentive contract for development. Tyler went on to say that he was experimenting with a new form, the CPAF contract. He talked about his "infamous" contract that was getting so much publicity.(1) The CPAF era had begun.

Subsequently George Vecchietti, then Director of Procurement for NASA and Jim Cravens of his staff, gave several talks on its merits and potential use. They strongly endorsed the Award Fee. The Award Fee bandwagon had started to roll.(2) Then in 1967, NASA published its Interim Guide (draft) on Award Fee, in which George Vacchietti wrote the preface. In his remarks, Mr. Vecchietti defined the Award Fee as a management process.(3) In NASA's official Award Fee Guide, the 1967 NHB 5104.4, he defined the application of the Award Fee to be applicable between that of the CPFF contract and CPIF contract. On its merits, he commented, "In many cases, the motivation effect may be stronger in an Award Fee contract than in a cost plus incentive fee contract." And in a prophetic statement, he noted, the "full maturation of experience with this tool is yet to come."(4)

Much has happened since George Vecchietti wrote that 19 years ago. The Award Fee has gradually been applied to almost all spectrums of procurement. NASA went on for a while to use the contract almost exclusively, and the DOD has gradually increased the scope of its use. But the relative use in terms of total DOD dollars has always been modest. However, some of the allure has gone off the Award Fee. In recent years, there has been considerable concern about "potential giveaways." NASA in `85 and `86 had reduced its use. It used more of the traditional CPIF and FPI forms. The Navy, badgered by charges of abuse, also cut back. It appeared that the pendulum had begun to swing against the CPAF. Are these criticisms valid? Is this renewed and cyclical cynicism, touted and fired up by congressional and senate committees a well-founded concern? Or is the CPAF, in the words of the Navy's late John Flaherty, "the best management system that exists for the development of complex systems?"(5)
In April of `83, I started a journey of inquiry to unravel, if possible, many of the divergent opinions. The final 286 page report of 1986/87, "The Effectiveness of the Award Fee Concept"

presented it findings. This paper synopsizes my work. The following topics are covered:

I. The History of the Award Fee Concept
II. Design and Use of the Award Fee Contract
III. Critical Issues
IV. The Fundamental Questions
V. Hypotheses
VI. Conclusions on Critical Issues
VII. Conclusions on Fundamental Questions
VIII. Conclusions on Hypotheses
IX. Some Precautions
X. The Golden Rules

## I. THE HISTORY OF THE AWARD FEE CONCEPT

It is not clear precisely when or how the Award Fee contract evolved, but it seems to have evolved as a natural variation of the cost incentive and redeterminable contracts. All the pieces were there. Table 1 outlines the approximate evolutionary process.

TABLE 1

Events in Development of Award Fee

1. The first actual reference I have found to the Award Fee concept was in a 1948 meeting of the "Committee on National Policy," held at Yale. Quoting from the proceedings of the meetings, "attention was directed toward another variation of the CPFF contract...a cost evaluation contract. Under this type of contract, the performance would be evaluated upon completion of the contract on the basis of certain factors specified in advance, such as the efficiency of labor..."(6)
2. Variations of the Award Fee were used in aircraft maintenance and overhaul in the 1950s.(7)
3. The early procurement guides of the late 1940s and early 1950s do not mention the Award Fee, but they mention redeterminable type contracts that had facets of the Award Fee concept.(8)
4. The DOD, in its summation of contract usage from 1951 to date, does not show the Award Fee until 1968.
5. Secretary McNamara mentioned the Award Fee contract concept in a speech he gave in 1961 to the NSIA in a June 15th joint industry-DOD symposium.(9)
6. Scherer, a Harvard professor at the time, in his works on incentives, recommended "after the fact evaluations" in 1962 and 1964.(10)
7. The ASPR committee approved the use of the Award Fee on an experimental basis in November, 1963.(11)
8. Apparently, the first "modern Award Fee contracts" were developed in 1961 and 1962. A CPIF that included an Award Fee contract was issued by the Navy to be effective in July of 1962 for Logistics Support Operations at Kwajalein Island. It was a CPIF that had an Award Fee provision, not a pure Award Fee.(12)
9. The Navy's first "pure Award Fee" was issued by its purchasing office in Los Angeles in 1 March 1964 for the Operations and Maintenance of Instrumentation Systems and Associated Range Facilities.(13)
10. The first NASA Award Fee was negotiated by the Space Nuclear Propulsion Office in Cleveland in 1962. It was for the time period from 1 October 1962 to 30 September 1963. It covered the R&D of a nuclear powered rocket engine (NERVA). In a closely related time frame, the negotiations of the maintenance and engineering contract for the Mercury Manned Space Flight Network were conducted in 1962 by the Goddard Space Flight Center.
11. Mention was made of the "infamous Award Fee contract of NASA" in a seminar of the American Management Association by Gordon Tyler in August 1963. He noted that the concept was getting a lot of publicity. He said "the Award Fee was basically a cost contract with a fixed fee with an opportunity to earn more fees through a unilateral subjective evaluation by the government."(15)
12. The <u>1962 Incentive Contracting Guide</u> written by Harbridge House for DOD does not mention the Award Fee. Neither does the <u>Harbridge House 1963 Training Manual</u> used by NASA and DOD.(16)
13. The <u>1965 DOD Guide</u> included the Award Fee under "exceptional methods of structuring multiple incentives." It noted that the Air Force, Navy, and NASA were experimenting with the Award Fee and that a deviation was required for its use.(17)
14. The <u>1965 NASA Incentive Contracting Guide</u> featured a chapter seven on "Award Fee."
15. A Harbridge 1966 seminar on incentives had examples of the Award Fee.(18)
16. The first official contracting guide on the Award Fee came out in 1967 and was published by NASA.(19)
17. Jim Cravens and George Vecchietti of NASA spoke of the Award Fee contracts in a series of talks given in 1965 and 1966. They noted a study funded by NASA with Ray Hunt of Buffalo to study the Award Fee.(20)
18. The Booz-Allen study of NASA's contracts in 1966 noted the increasing enthusiasm across NASA for the Award Fee contract.(21)
19. Between the authorization of the Award Fee contract by the ASPR committee in 1963 and the publication of the Award Fee Guide by NASA in 1967, there were 140 Award Fee Contracts written with 90 contractors totaling 1.1 billion dollars.(22)
20. The Air Force apparently wrote its first Award Fee in 1969. The Army, which had been the last service to use the traditional incentives, was also the last to adopt the Award Fee.(23)
21. The Award Fee has never accounted for a very large proportion of DOD expenditures. Since 1968, its use averaged around one to three percent. (24)
22. In 1985, both NASA and the Navy have reduced and/or restricted the use of the Award Fee contract.(25)

## II. DESIGN AND USE OF THE AWARD FEE CONTRACT

What was the intended use of the Award Fee contract? This section summarizes the official guidance on its intended use. The early NASA and DOD incentive contracting guides provide insight into the government's original intent.
The first incentive guide, written by Harbridge House for the DOD, and published in August, 1962, does not mention the Award Fee.(26) But both the NASA and DOD incentive contracting guides, published separately in 1965, do mention the Award Fee.(27)

The <u>1965 DOD Guide</u> discusses Award Fee under the section on extra exceptional methods of structuring multiple incentives in part VII-C. The <u>NASA Guide</u> reviews the topic under part VII, which was specifically on the Award Fee contract.

Subsequently in 1967, NASA published a guide devoted solely to the Award Fee.(28) A joint DOD-NASA general guide on incentives published in 1969 provided guidance.(29)

The suggested use of Award Fee in the 1965 DOD Guide was for Advanced Development. A multiple incentive contract formula was recommended. To quote, "often at this stage, neither the government nor the contractor have enough information to define program requirements. Thus, an Award Fee might be preferable to a CPFF."(30)

NASA took a different perspective in its 1965 Guide. The recommended use was for non-personal services. The policy required that NASA personnel give serious consideration to the inclusion of a CPAF arrangement in any sizable contract for non-personal services where "a firm fixed price or formula-type incentive is not feasible and where the potential benefits outweigh the increased burdens of administration."(31)

When NASA came out with its 1967 Guide, it added some additional thoughts on Award Fee usage. Its first "interim guide" (NPC 403) described the Award Fee contract as a management tool and authorized it for use for non-personal services and for the procurement of "hardware in the development phase," but they recognized that the "widest application would be for non-personal services and support services."(32) However, in the later 1967 Guide (NHB 5104.4), it again modified and/or clarified its intent by ascribing the Award Fee for use "in the spectrum of available contracts between the CPFF and the CPIF contracts." It added that "the motivational effect of the Award Fee may be stronger than that of the CPIF."(33) In both guides, it was recognized that the Award Fee could be combined with the CPIF (CPAF/IF and CPIF/AF).

The 1969 Combined DOD/NASA Incentive Contracting Guide was written "to minimize complexity and increase the effect of motivation." Under the section on contract usage, it placed the CPAF between the CPFF and the CPIF, and also suggested its use for the research and exploratory phase of acquisition (contract definition phase). The 1969 Guide also stated that the purpose of the Award Fee incentive was to achieve the government's goals in a cost effective manner.(34)

The DD350 did not collect data on Award Fee contracts. Therefore, estimates are general at best. However, some insight can be gained from the totals reported on the annual report of the GAO. The Award Fee first appeared in these statistics in 1968. Since that year, total expenditures on Award Fee have ranged from one to three percent of total DOD dollars spent. Of the services, the Navy's use has been the highest, at about six to seven percent in 1983. In that same year, the Air Force had 1.7% and the Army had 2.7%.(35) Finally, in 1967, when the NASA Award Fee Guide was published, there had been as of that date 140 Award Fee contracts written with 90 contractors totaling 1.1 billion dollars.(36) See Chapter One of my study for a detailed graph showing contract use since 1951.

## III. CRITICAL ISSUES

In reviewing my research over the last nine years on acquisition and incentives, several critical issues surfaced time and again.

TABLE 2

Critical Issues

1. The fees might loose their impact over time and they might "creep up over time."
2. The grading process might be highly biased by the personalities involved.
3. The participants might play to the instrument.
4. The reward process, particularly the grading of individuals, might place a destructive pressure on the corporation.
5. The personal agenda (to get a good grade) might distort the real purpose of the procurement, and lead to goal distortion.
6. The fees might be a giveaway. Over time, the fees go up.
7. The fabric of the government-industry team relationship might be irrevocably strained, thus distorting the team's cooperative efforts.
8. The normal attrition of personnel due to retirement and transfer might make it almost impossible to administer the Award Fee agreements fairly.
9. The administration costs of an Award Fee might outweigh the advantages of its use.
10. The Award Fee might require too much government involvement.
11. The contractor, by playing to the instrument, particularly at grading time, might distort the normal process and flow of business.
12. There might not be any generally accepted way to structure an Award Fee contract.
13. Award Fee contracts might elevate "the level of gamesmanship."
14. Perhaps there is a cannibalization effect. The importance of a grade on one program might distort the company's efforts in other program areas.

## IV. FUNDAMENTAL QUESTIONS

The "common wisdom" of the interviews and literature search identified ten fundamental questions. These varied somewhat by service and department, but there were many common threads.

1. Where should the CPAF contract be used?
2. Is there a dollar threshold below which the CPAF ceases to make sense?
3. What kind of factors and behaviors are suitable as evaluation criteria?
4. If something is intangible and virtually impossible to quantify, should it be used as a criterion?
5. Who should be involved in the grading process?
6. Is this bias in the grading process? Is it destructive?
7. How often should performance be measured?
8. What kinds of rewards are appropriate?
9. How can the administrative process be constructive instead of destructive?
10. Should the Award Fee be used in combination with other contracts?

## V. THE HYPOTHESES

There were seventeen hypotheses. These are stated briefly.

1. Contractors do not have a rational, consistent approach to the management of their firms.
2. Executives are primarily motivated by their own well-being. They put their own goals ahead of the firm's.
3. Short-run profit is not the driver on corporate behavior.
4. There is great difficulty in defining specific goals on complex systems.
5. A team approach by government and industry is preferable to letting the marketplace function independently. Close teamwork is preferable to arms-length relationships.
6. The benefits of the Award Fee are significantly greater than its costs of administration and implementation.
7. "Master/slave" relationships develop.
8. Innovation and creativity can be hampered where the "whims of the government" have the highest priority.
9. The organizational visibility of key corporate executives and managers results in overall improved contractural performance.
10. Common motivational agendas exist for contractors.
11. Uncertainty can be minimized through a concerted, dedicated, team effort.
12. Cost-maximization is not the goal of contractors under an Award Fee.
13. Meaningful criteria can be defined that can be fairly evaluated.
14. Meaningful criteria can be developed that relate to desired contract outcomes.
15. Contractors do respond appropriately to the Award Fee "grades."
16. The "grades" work; they get the contractor's attention.
17. Contractors, by virtue of the Award Fee contract, do something over and above that which they would have done under another contract type.

These concerns, questions, and hypotheses provide the focus of the study. The conclusions are each presented in the following sections. In the final section, some precautions and recommendations are offered.

## IV. CONCLUSIONS ON THE CRITICAL ISSUES

As noted, fourteen critical issues were identified. Conclusions on each are offered.

1. <u>The Fees Tend to "Creep Up"</u>
There is, indeed, fee creep, but it is not at all clear if it is due to abuse. It might mean that the Award Fee is working. Eventually, the fee as a motivation loses its "punch."

One can often predict beforehand with accuracy what the final fee level will be. Patterns develop at each agency or center. Grade creep needs to be studied. Mechanisms have to be developed to mitigate the problem.

2. <u>The Grading Process is Highly Biased by the Personalities Involved</u>
The participants can be and probably are biased, but the checks and balances mitigate against grave unjustness. The chief danger is autonomous control by an FDO on whom there are no checks or balances. Rebuttal systems should be incorporated, as well as frequent, informal evaluations and plenty of "daylight." Let everybody know what is going on; document the process well.

3. <u>The Participants Tend to Play to the Instrument</u>
They do. Such behavior is to be expected. The key is to minimize the game playing. Experienced personnel can tell the difference between real progress and the appearance of progress. "Playing to the score card" can be a serious problem, but a professional well-trained staff should be able to minimize its impact.

4. <u>Destructive Impact on the Company</u>
There does not seem to be a destructive impact on corporations. Just the opposite might well be the case. The communication, the frequent interaction, the clarity of goals, the immediate feedback, the opportunity to shine before one's peers, the opportunity to do one's job and receive immediate feedback of a positive nature, all argue for improved corporate life. The teamwork and team spirit that so often are the hallmarks of the Award Fee contract most likely have a very positive long run impact on the government and the industry team members.

5. <u>The Personal Agenda, the Need to "Be a Winner" Might Distort the Real Purpose of the Procureman</u>
Some of this occurs, but the checks and balances noted earlier should offset the capricious actions of individuals. However, caution must be exercised that the tail does not start wagging the dog. The process can become an end in itself, as some have testified during the interviews. Perspective is important.

Congruency is the key. The elements graded must have clear relationships to the desired outcomes. They must be adjusted over the life of the program as need be. Participants must ask themselves frequently, "What is the real goal of the program?" "Do these goals selected for evaluation relate to the overall goals?"

6. <u>The Fees Might Be a Giveaway</u>
The goals of the Award Fee are contractor involvement, cost control and desired performance. An added fee potential is provided to motivate the contractor toward these goals. The real motivator, however, appears to be the evaluation and the unilateral assessment of the contractor's management team's actions by the government. Are fees given away in the process?

There probably are fees awarded that were "easy" to win. Is this bad? There seems to be too much concern about fee giveaways and not enough sensitivity to the goals of quality, maintained schedules, and avoidance of cost incurrence. This is an age-old problem. There is too much concern about the level of fees and too little about the costs. The Award Fee does improve quality schedule and overall performance.

7. <u>Destruction of the Government Industry Team Relationships</u>
There was some concern in earlier years that a master/slave relationship might erode the government-industry team. Just the opposite has occurred. The Award Fee, according to everyone's testimony, builds a team spirit, fosters communication at all levels, and instills a pride of belonging. It appears to have had some considerable success where other contract approaches have failed.

8. Attrition of Personnel Wreaks Havoc with the Evaluation Process
Turnover does create problems. When there is a turnover of key personnel, there is a loss of consistency and confidence. In a sense, everyone starts over. However, there are advantages. Turnover is one of the checks and balances which control program advocacy.

The longer the Award Fee process has been in being, the smaller the impact of turnover. The nuances of the Award Fee culture, once established, define the written and unwritten rules of play, and thereby dictate behavior. Finally, it makes a major difference where the turnover occurs. Changes of FDO's can have an enormous impact, but a change of a business monitor in a minor component of the program might go unnoticed.

9. The Costs Outweigh the Benefits
The benefits are greater than the costs in the opinion of almost all the practitioners. The benefits vary by application, size of company, and size of program. Bottom line, goals tend to be met under Award Fee organization.

10. Too Much Involvement in Contractor Operations
There is probably some truth in this, but the practices vary widely and it is difficult to measure. The government's attitudes varied from those of the contractor. Generally, the government likes the involvement, whereas the contractors have mixed emotions. The contractors like cost-type contracts, but resent too much day-to-day interference.

11. The Contractor Playing to the Instrument Distorts the Real Purpose of the Procurement
Yes, there is a danger that the process can become an end in itself. But the research does not suggest that this is widespread or a serious problem. A key is to make sure that the goals of the program are directly reflected in the criteria of evaluation.

A constant reevaluation is important. As the program matures, criteria and related evaluation approaches need to be constantly challenged and modified as deemed necessary.

12. There is No Commonly Accepted Way to Write an Award Fee Contract
There is a wide range of variation; perhaps that is how it should be. No two contractors are the same; their motivations are varied and changing. In order to be effective, Award Fee contracts have to be adapted to the motivational mix of the contractor and his employees.
There are, however, accepted principles on how to use Award Fee contracts. In the last 20 years, practitioners have developed hands-on experience of what works and what does not work. This experience must be documented, collected and published.

13. Award Fee Contracts Have Elevated the Level of Gamesmanship
Overall, yes, but it varies on how one defines "gamesmanship." With the Award Fee, the government has more day-to-day insight into the contractor's actions. The contractor's activities are more visible to the government. Under Award Fee contracts the government is able to get organizational penetration. The behavior fostered by the Award Fee process is healthier than that fostered by the "arms length" approach. Openness, detailed planning and goal congruence all suggest less destructive gamesmanship.

14. Cannibalization
The "overlap" phenomenon, often reported by the participants, suggests that cannibalization is not serious. Quite the opposite, apparently the benefits of the Award Fee process tend to benefit the other in-house contracts. The improved contractor-government communication is but one example. Over time, the Award Fee culture permeates the entire organization. Thus, all the programs tend to be treated like an Award Fee, even when they are not on an Award Fee contract. This phenomenon has a wide range of implications and should be studied.

## VII. CONCLUSIONS ON THE FUNDAMENTAL QUESTIONS

1. Where Should the Award Fee be Used?
It is currently being used across the spectrum of acquisition, and I see no fundamental reason to restrict its use. It is generally more applicable to cost-type environments than is a straight fixed price contract, and some twenty "bedrock" fundamental questions were studied. Ten are reported on here. These ten cover the major ingredients of design and use. It is useful both by itself and in combination with other contracts.

Its natural niche is in its pure form, in lieu of CPIF and CPFF contracts, but variations could be envisioned for use with fixed price type contracts. Further, its use has more appeal in the development phase than in production.

Wherever it is important to have control, to develop a team effort, or to get the involvement and attention of the contractor, the Award Fee is applicable. The Award Fee process is a management system; it is far more than just a contract type. The decision to use an Award Fee is fundamentally a selection of a management approach.

2. Is There a Minimum Dollar Amount?
There are several selection criteria that are important. The dollar amount is just one of them. Various levels have been suggested. Other factors such as those mentioned above, are more important than the dollar amount.

3. Factors and Behaviors Suitable to Evaluation Criteria
What elements should be used? There are no absolute rules. A wide range are successfully employed. But there are some guidelines. Bottom line, you've got to hook the agenda of the executive team working on the program. Some general observations are offered:

a. The criteria should be linked to personal as well as company goals.
b. They should foster goal congruence.
c. They should be clearly linked to the government's goals.
d. They should be definitive and specific rather than general and cosmetic.
e. They must be such that when accomplished, the government's goals are met.

4. Should Intangibles Be Used as Criteria?
What is an intangible? Presumably, if one could quantify all the variables, then according to the Award Fee Guide, traditional incentives, rather than an Award Fee would be appropriate.

All measurements have aspects of tangible and intangible characteristics. Intangibles are unavoidable. Judgment is always a factor. It is more important to think about the kinds of things that are related to outcomes than the extent to which they are quantifiable.

5. Who Should be Involved in the Grading Process/Elimination of Bias Involvement?

There is a wide range of processes in practice. Hunt, Easley, Nielsen, Runkle and Schmidt have, for example, documented several and have commented on same. The people involved are a function of the scope and complexity of the program. Several key points apply:

a. There should be a detached third party.
b. There should be representation from each activity involved.
c. An interactive process with contractor involvement is often useful.
d. The participants should have some hands-on experience; some should have regular interaction with the process being monitored.
e. There needs to be checks and balances.

6. Bias

There is no way to eliminate bias. We can, however, minimize it. Sterling Institute, Easley, Wright, Meiners, and Booz-Allen, among others, studied this issue. Some points that apply follow:

a. Protect against program advocacy.
b. Provide a lot of visibility to the process.
c. Have disinterested third parties involved.
d. Have checks and balances.
e. Provide for a rebuttal by the contractor.
f. Have a bias monitor/evaluator.

7. How Often Should Performance Be Measured?

It depends on:

a. The nature of the program
b. The life cycle characteristics
c. The complexity of the development effort
d. The evaluation structure
e. The stage of the program

8. What Should be the Nature of the Reward Structure?

The success of the Award Fee is critically linked to the type or kind of reward structure. Please see the full discussion on this point in the report. Some highlights are offered.

a. Rollover should be encouraged for most situations.
b. The pattern of rewards is a function of the goals.
c. "Distributed Practice" versus "Big Bang" are two opposing methods.
d. The literature on motivation and behavior patterns with variation of rewards is applicable. It needs to be incorporated into the government literature and guidance.
e. Penalties can be more useful than rewards in many situations.
f. People's egos are more relevant than the companies profits.
g. The Award Fee should be tied to personal agendas primarily...not corporate.

9. The Administrative Process Being Constructive

No doubt about it. Award fee contracts can substantially increase the administrative burden. It requires experienced, competent personnel to take full advantage of the Award Fee contract's potential. But they "work" often when inappropriately administered. Some ideas are listed.

a. Have experienced people interfacing with contractor.
b. Minimize meaningless paperwork.
c. Match the process to the program.
d. Match the process to the stage of the program.

10. Use of the Award Fee with Other Contract Types

It can be and is used in a wide variety of arrangements with most of the other contracts. See the examples in the report under Award Fee and Other Contract Uses.

## VIII. CONCLUSIONS ON THE HYPOTHESES

1. Contractors do not have a rational, consistent approach to the management of their firms.

Comment: My conclusion is that they do not, if stated goals are the criteria. Firms tend to optimize the goals of the people running them. Middle management optimizes its own personal goals and so on thru the organization. In all cases, the element of emotion plays a major role in the decision process. There is an illusion of rationality. And, of course, the executives and workers view themselves as logical and rational. This argues for the Award Fee's applicability.

2. Executives are primarily motivated by their own well-being. They put their own goals ahead of the firm's.

Comment: As noted above, the answer is clearly yes. Goal congruence is minimal. People are self-seeking. If they can get there thru the organizational goals, goal congruence is high. If they cannot, it is low. For most, goal congruence is nonexistent. It suggests that the Award Fee idea should have wide application. Profit is not the driver with Award Fees. 3. Short-run profit is not the driver in corporate behavior.

Comment: It is not. There is always a variety, a mix of complex factors at work. It's one of the reasons that the Award Fee can work so well. It harnesses a wide range of motivational factors. It can be tailored to the particular situation.

4. There is great difficulty in defining specific goals in complex systems.

Comment: It is, indeed, difficult. Certainly optimizing profit is too broad and too long-run a handle on motivations. But the Award Fee can be structured to interface with the motivational matrix. This can be accomplished even when the specific motivational patterns remain vague.

5. A team approach by the government and contractor is superior to letting the marketplace function.

Comment: My conclusion is yes. I would argue for close teams of industry and government. I support the industrial-military complex. Organizational cultures need time to mature. Quality and trust are a function of long-term relationships. This is particularly important for complex undertakings.

6. The costs exceed the benefits.

Comment: No. For large complex systems, the benefits far exceed the costs. One can imagine relatively small, far less complex undertakings that would benefit from an Award Fee approach. There is a minimum threshold, of course. But it is lower than we had previously concluded. Rules of thumb abound among the practitioners. A common one is $25 million. I would go lower. The point is the

7. Unilateral assessments can be made fairly.
Comment: Not completely, but adequately to make the system function effectively. Checks and balances provide adequate control. Most decisions, in fact, are not really unilaterally determined. There is a lot of give and take.
8. A master/slave relationship can be avoided.
Comment: This has not occurred. Checks and balances and the economic and political strength of the contractors have mitigated the problem. There is potential for abuse, but it appears to be rare.
9. Innovation and creativity can be enhanced under Award Fee contracts.
Comment: There is no evidence to suggest the limitation or constraint of creativity and innovation. In fact, many practitioners suggest just the opposite has occurred.
10. Common motivational agendas exist for contractors.
Comment: Common enough is the answer. Patterns do emerge for given niches of industry. When one learns how to develop an Award Fee program to build a battleship, the process can be replicated to build other battleships. This then can be adapted to the particular contractor.
11. Motivational agendas exist that are common across industry.
Comment: There are some common motivational threads that can be used in the Award Fee, but not much is known about specific motivational agendas of aerospace contractors. Research in this area is vital.
12. Uncertainty can be minimized through a concerted team effort.
Comment: Yes. The team effort and the discipline that goes into the Award Fee does minimize the uncertainty element.
13. Cost maximization is not pursued under the Award Fee.
Comment: I am not so sure. But the cost control aspect is attractive compared to options available. It depends on how well the Award Fee is structured. If the process allows the contractor team to get good grades and to optimize costs, there will be cost optimization.
14. Meaningful criteria can be fairly evaluated.
Comment: Yes, and more experience makes the job easier. "Street smarts" are important. There is a learning/experience curve. There is a lot of trial and error in the earlier stages.
15. Criteria can be developed that relates to outcomes.
Comment: Related to #14 above, and again the answer is yes. Practice and experience are critical factors.
16. The grades work to get the contractor's attention.
Comment: Yes. The contractors are very concerned about the grades received. Visibility is important. It's important that individuals get grades, not just the corporation.
17. Contractors, by virtue of the Award Fee, do something more than they would have done under other types of contracts.
Comment: Yes, they do. Almost all the practitioners conclude that the Award Fee works.

## IX. SOME PRECAUTIONS

By far, the preponderance of researchers have liked the Award Fee. They have concluded, with minor reservations, that the Award Fee contract works. I have concluded similarly. Yes, the Award Fee achieves organizational penetration. Yes, the Award Fee gives the government some control. Yes, the Award Fee fosters a team environment and develops a clearer picture of the goals. But prudence suggests some caution. If the Award Fee contract is inappropriately designed and administered, it can be an invitation for abuse. Specifically, I see several potential pitfalls.

TABLE 3
Some Precautions

1. The administrative burden can be massive.
2. It can demand too much time of top management.
3. It can be made to function like a CPFF contract.
4. It can permit excessive government involvement.
5. It can foster paternalism.
6. It does require a lot of paperwork.
7. It nurtures advocacy relationships.
8. It can foster a lax cost mentality.
9. It can be an invitation to contractors to optimize costs.
10. It takes an experienced team to make it work.
11. It might give the contractor an edge in the "gamesmanship" struggle.

## X. THE GOLDEN RULES

This has been a long journey, hopefully, the reader will have found some food for thought within this paper and within the covers of the full report. The Award Fee concept offers unique features that have eluded the acquisition community to date. If we can take advantage of these potential benefits and avoid the hazards implied, it has enormous potential across the acquisition spectrum.
The full report offers recommendations on all the major issues. Please refer to it. Some "street smarts" collected from the practitioners are noted below:

TABLE 4
"Street Smarts"

1. Make the fee pool large enough to be meaningful for the particular situation.
2. Pay the fees earned promptly.
3. Do not pay fees unless minimum performance is achieved.
4. Set the fee base low; combine with a large fee pool.
5. "Back load the Award Fee pool" to make sure that the contractor does not earn a large fee for a product or service that either works poorly or ultimately does not work.
6. Work closely with the contractor to make sure he understands the contract requirements and processes: contractors unfamiliar with the Award Fee take two years to "learn the game."
7. Make sure there are carefully defined milestones spread out over the life of the contract.
8. Do not make it complex.
9. Reevaluate regularly the structure of the ratings and related processes. Adapt as necessary. Be flexible.

10. Look on the Award Fee contract as a management process, not a contract type.
11. Performance standards must be established for each evaluation period, and revised as necessary.
12. Get the contractor involved in the evaluation process. Self-evaluations are important.
13. Do not overburden the contractor with evaluations. They can take up to two months to get ready.
14. The composition of the Award Fee Evaluation Board is important. Stability and experience is vital.
15. Use the Award Fee process to communicate regularly with the contractor.
16. Use the Award Fee process to keep the contractor appraised of the government's wishes.
17. Keep the evaluation plan reasonable, feasible, comprehensive, simple, and flexible.
18. Make sure all participants are trained and knowledgeable about Award Fee contracts and their responsibilities. This is particularly important for technical monitors.
19. All participants in the evaluation process should be briefed together and talked through thoroughly how the process is to work. This should be done regularly.
20. Keep old plans that worked and use as applicable.
21. Shake up the contract every couple of years. The Award Fee process loses its effectiveness after two or three years. Changes have to be introduced to keep the motivations fresh.
22. Make sure the Fee Determination participants put in writing why recommended fees are changed. These changes and their related reasons should be communicated to subordinates.
23. Finally, there is no right or wrong way to write an Award Fee. It is a process of management which must be tailored to the situation.

## BIBLIOGRAPHY

There are 287 documents noted in the bibliography in my Award Fee research document on which this article is based. Space does not permit them to be reproduced herein.

The numbers referenced throughout this article are keyed to that full bibliography. For example, reference two in this article pertains to items 43 and 44 in the main bibliography.

| Number in Article | References in Research Document Bibliography |
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INCENTIVE CONTRACTS - A WAY TO REACH A SETTLEMENT

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ABSTRACT

Fixed price contracts have been proclaimed as the most appropriate type of contracts for the Government to negotiate to the detriment of any consideration of the incentive type contracts. This tendency is especially true for production contracts where clear, firm specifications are available to enable the contractor to perform the required work. In many cases, however, the use of an incentive contract might prove a valuable tool for contracting officers.

This paper will explore the use of fixed price incentive and cost plus incentive fee contracts where negotiations have become deadlocked due to substantial differences in negotiation positions between the parties involved. In these situations, there is a natural tendency to split the difference which can result in a final settlement in which the contracting officer is left feeling uncomfortable.

Several options open to both parties accompanied with graphical representations will also be presented. These options afford incentives in the form of rewards and penalties that both the Government and the contractor can accept. Also provided are practical solutions and methods for resolving the negotiation impasse, thereby enhancing a settlement to a fixed price incentive contract or an alternative incentive contract.

A case study of an actual program will be used to demonstrate the methods proposed to achieve acceptable compromises during negotiations. The case study covers an engineering development program in a mature phase of development. This study includes the use of variable share lines in the same contract and offers an innovative method whereby agreements can be reached in even the most difficult negotiations during any phase of the product life cycle.

INTRODUCTION

Historically, the use of incentive contracts for Government procurement has existed since the early part of the 20th century. During the Kennedy era, use of incentive contracts became quite fashionable when the Secretary of Defense, Robert McNamara, directed their use in the early 1960's. McNamara's direction reflected a concern by the Department of Defense (DoD) that the various purchasing elements were depending too heavily upon the cost plus fixed fee contracts for the purchase of weapon systems and weapon components.

As a result of the direction for the Secretary of Defense, Government procurement personnel were familiarized with incentive contracting procedures through training classes, publications on incentive contracting, and "hand's-on" experience. More recently, emphasis has deminished to such an extent that the contracting community has eased back into the relative comfort of pre-1960 contracting tradition. The incentive contract types are included in the Federal Acquisition Regulations (FAR) as an appropriate contract arrangement. The incentive contracting training promotes the use of incentive contracting in the product development stages of the life cycle. In fact, it would be safe to say that there exists a serious lack of emphasis on incentive contracts in DoD today except for the incentive contract training. Nevertheless, due to their decline in popularity and/or lack of enthusiasm and understanding on the part of Government contracting personnel, incentive contracting arrangements are seldom employed during the production phase of the product life cycle, to the detriment, sadly, of all parties concerned.

By the time the acquisition cycle reaches full scale production of the systems and component breakout, the contractual instrument primarily selected and negotiated is the fixed price contract. The fixed price contract is the ultimate contractual arrangement in the eyes of the contracting community because of its relative simplicity, predictability and ease of administration. When contracting officers use the fixed price contract, they have made an attempt to shift all of the cost/price risk onto the contractor.

There is an obvious reluctance on the part of Government contracting personnel to depart from the relative safety of this risk-shifting fixed price contract arena. Contracting Officers have beat into their head that they must shy away from the higher cost risks borne by the Government in other contract types. Mere mention in passing that an incentive contract might be an aid in overcoming negotiation deadlocks is usually met with negativism and rejection, and the advocate quickly assumes the status of "persona non grata." The matter should not be allowed to drop here, however, as there are potentially too many advantages to be gained by more serious consideration of incentive-type contracts in difficult negotiations.

The reason most contract specialists tend to shy away from the use of the incentive contracts should be examined more closely. Human nature tends to resist anything that is not performed habitually or involves sailing in uncharted waters. These psychological aspects, combined with inexperience and lack of training, are the key inhibiting factors which undermine attempts to explore differing vistas of contracting methodology.

## COMMON USES OF INCENTIVE CONTRACTS

Incentive contracts are commonly used, with a great deal of success, in the latter stages of the research and development phases of system and product development. Initially, in this latter phase of R&D; a cost plus incentive fee contract is used to promote effective use of limited funds during advanced engineering development. In larger system procurements, multiple incentives are employed to promote technical advances coupled with cost restraints. In these multiple incentive arrangements, the negotiator develops, with the aid of the technical people, a value statement. The value statement serves as a yardstick by which the value of certain technical elements are established in cost trade-off arrangements by "goal posting." In such arrangements, miles per hour, distrance between fueling, and/or mean time between failures are scaled to dollars of cost and program objectives. In this manner, the contractor cannot achieve a greater profit/fee for higher performance and overrun cost in attaining that higher level of performance than was originally intended. What is suppose to happen in multiple incentive arrangements is that higher cost targets are developed to insure that fee dollars are subtracted in a shared dollar ratio from the amount of fee earned in other incentive elements. The idea is to assure a direct relationship exists between higher costs and better performance of the product produced. This tricky arena is where the balancing of the various cost and performance bogies must come into play. Multiple incentives are a way to force a contractor to manage every element of the contract to achieve a good product at a reasonable cost.

The incentive contracts that will be discuss in this paper will concentrate on cost objectives in a Cost Plus Incentive Fee (CPIF) contract. In later stages of system maturity, the Fixed Price Incentive (FPI) contract may be the best contract type to negotiate. This phase is followed by the fixed price contract phase of the contracting evolution. The fixed price contract is considered by many contracting personnel the ultimate incentive contract. For every dollar that is saved, the contractor benefits 100 percent and thus obtains a dollar-for-dollar increase in profit if the contractor underruns the original negotiated cost target. In the case of a fixed price contract, this cost target amounts to the sum total of the direct and indirect costs that the parties agree upon to be reasonable for the performance of work on the contract.

What happens when the Government and the contractor cannot agree on the exact dollars which should constitute the cost base of the fixed price contract? In many cases, the negotiator is pressured to settle and, consequently, there is often a splitting of the difference between the Government's and contractor's positions at that point in the negotiations. If the Government's position in a negotiation is $100,000 and the contractor's is $110,000, a reasonable settlement might be to establish the cost base at $105,000. In a fixed price contract, the result might be a $5,000 windfall for the contractor. If the contractor is able to meet the contract requirements for $98,000 and the contract settlement was $105,00 profit (in this case 10 percent) or a grand total of $17,500 actual profit for the company. This situation would amount to 17.5 percent profit on the original Government position of $100,000.

How could the Government negotiator have better served the public's interest in this case? The use of an incentive contract in this situation might well be the answer. The contract can be structured so as to protect the Government and the contractor.

## WEANING NEGOTIATORS FROM EXCLUSIVE USE OF FIXED PRICE CONTRACTS

There is considerable pressure from different sources applied to contracting officers of the Government to award fixed price contracts. This pressure stems from the certainty that a specific price will result through assumption by the contractor of all the uncertainty at that price. Unless the contractor is inexperience or has total command of all costs, good contractors will include contingencies in his price to cover all the cost risks for the performance of work. The contractor recognizes that the Government liability is limited to the payment of only the dollars identified as the fixed price. As indicated above, in a poor settlement, the Government could end up paying the contractor more profit than was ever anticipated during the negotiation phase. This may come about not so much by the contractor managing better but rather by his astute negotiations before award of the contract. Government contracting personnel need to be made aware of and develop expertise in using of all the different types of contracts that are authorized and identified in the FAR. The flexibility which will result might substantially benefit the parties to Government contracts.

Should all this rhetoric be interpreted to mean that the Government should refrain from using the cost plus fixed fee contracts? The answer is not at all, but ONLY in those cases where the cost plus fixed fee contract is clearly the most appropriate. It can be employed advantageously in settling of letter contracts or ceiling priced delivery orders when negotiations have reached a stalemate and most of the work has already been performed by the contractor. Moreover, consideration should be given to cost plus incentive fee contracts, particularly for production contracts where wide differences exist and the Government is not wavering on its cost base position. One of the major concerns is to ensure that the Government does not pay more for the items to be purchased or work to be done than is reasonable based upon the cost and technical evaluations performed. How can the parties be protected when both have reasonable doubts on the exact amount needed for contract performance? A decision to make use of the appropriate contract type is the solution. An explanation follows of one method that can be employed to structure an incentive contract which will alleviate these doubts. Let's analyze in detail the normal cost plus incentive fee method for use in reaching settlements in difficult situations.

CASE STUDY #1

Let's examine a hypothetical case in which the Government and the contractor are negotiating for purchase of 5,000 Special Purpose Rifles. Assume that the contractor has submitted a cost proposal of $302.50 per rifle. The cost breakdown includes the following:

$75.00 Material costs
25.00 Material Overhead

$75.00 Direct Labor
75.00 Overhead

$25.00 General and Administrative Expense

$27.50 Profit

$302.50 Total Price

Total Fixed Price Contract $1,512,500.00

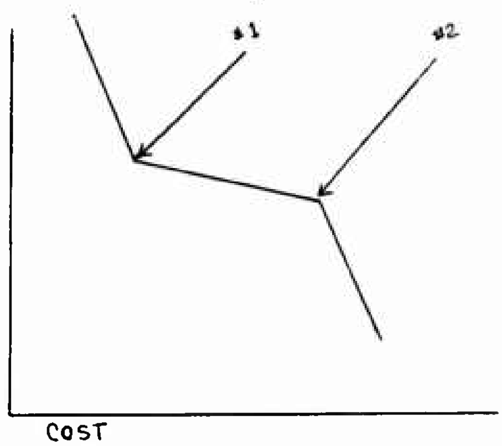
During the negotiations, the Government takes exception to the contractor's proposal in material costs, direct labor, and overhead accounts. The contractor has projected sales of $10,000,000 on which the contractor had developed overhead cost charges allocated to various contract proposals. The Government looks at all of the sales projections and notes the contractor has proposals that were submitted to several Government purchasing offices that were not included in establising overhead charges (technically the contractor is correct because there is a chance than an award will not be made). The Government determines that total sales, based upon anticipated award on one or more pending Government contracts, would be $15,000,000. This could result in a dilution of contractor's overhead and G&A accounts by an addiional $5,000,000 of sales (50 percent increase in sales). The impact of this dilution would be $141,700 reduction on the cost line of the contract being negotiated. The contractor would be hard pressed to accept the Government's position. This kind of projection by the Government is a negotiation position and a common starting point. The Government's position can be defended based upon previous history. Therefore, there would be a substantial disagreement as to overhead costs.

How can this dilemma be resolved? The contractor could be difficult and hold out for his price. He might agree to some material costs and direct labor changes based upon another review of his estimates for the job. If this were the first time the contractor is to perform the work, then he might be reluctant to revise his estimates for the cost base. If the item has been produced by some other firm, there is always the possibility of competititon between the two firms, and the Government could negotiate with the two sources and thereby attempt to achieve a cost reduction.

In this particular case, let us assume the contractor is sole source and the Government is dealing with the second production procurement. The contractor has had some experience with the items, reasonable data on direct labor and material. The difficulties in negotiation would focus on the area of overhead absorption. In this situation, how can the best interests of both parties be served? The use of an incentive contract will fill this bill. When the negotiation bogs down, the Government might propose that a cost plus incentive fee or fixed price incentive contract be utilized. The target cost of that contract could be the Government's cost position. This would protect the Government from the contractor's making a windfall if the contractor receives award on all of the contracts for which the contractor is under consideration. This contract would also protect the Contractor if they do not receive those pending awards or only part of them.

Let's graph the proposed numbers (see figure 1). As can readily be seen, the proposed contract would provide the contractor an opportunity to share in any cost underrun from the Government's position on a 50/50 basis. On an overrun, the slope will be 80/20 to the contractor's position and then 50/50 for the balance. The contractor's sharing of the cost would also be tempered by a higher profit/fee at the target position.

Figure #1




The slope between #1 and #2 above indicates the 80/20 sharing of costs by the parties on that upward slope of the line. This slope breaks the step slope before points #1 and after points #2. The contractor shares 20 cents on each added dollar of cost between point $1 and point #2. Beyond point #2 the contractor's fee is reduced by 50 cents on each added dollar of cost experienced. Cost savings to the left of point #1 provides the contractor with 50 cents of added fee for each dollar saved. In Figure 1, point #1 is equal to $1,166,666 of estimated cost and the fee at that point is $116,666. At point #2 the cost is $1,375,000 and the fee at that point is $88,326. There remains an incentive to underrun or reduce costs not only to the left of point #1 but even between points #1 and #2. The contractor does not want to exceed costs to the right of point #2 because of loss of fee increases to 50 cents on each dollar of costs. Many contracting officers might consider the negotiation of the downward slope to zero fee and thereby eliminate a minimum fee arrangement.

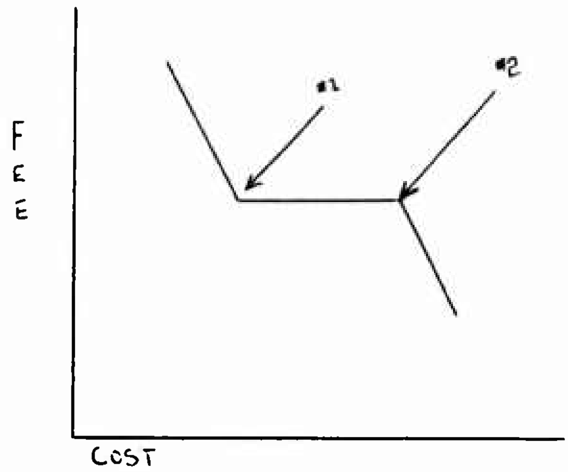
CASE STUDY #2

Looking at the same situation as before, but with a slightly different twist, assume the contractor will not settle at the Government's target cost. Let us examine what can be done in this case. The Government does not want to split the difference because it might establish a precedent.

One solution which comes to mind is a plateau of the fee/profit line in a cost plus incentive fee arrangement. The Government and a contractor are $141,700 apart in the example outlined above. What we actually have is a cost plus fixed fee contract on the cost line between the contractor and the Government's position. Before and after that point, we can have the steep sharing arrangement which would stimulate the contractor to manage the cost expenditures or to save costs and reap additional benefits. Figure 2 graphically depicts this arrangement. The graph does not show a minimum fee or maximum fee position. The maximum fee position in a CPIF contract must adhere to the limits established for cost contracts. The minimum fee arrangement can be as low as can be negotiated by the Government. The course material for incentive contracting recommends consideration of zero or even a negative fee in the cost overrun stages of the contract. The continued cost sharing is a concept used to prevent massive cost overruns in situations where the contractor might make a management decision to accept a minimum fee of 1 or 2 percent. By negotiation of zero or negative fee there is pressure upon contractor management to control costs from the beginning. In a negative fee position the contract becomes a cost sharing arrangement between the parties at the rate negotiated. In the example that is graphed the arrangement would be 50/50 if the line was extended down below the line. As we can see, this is a very straightforward, simple solution to the dilemma which might result in the negotiation of a fixed price contract at a cost estimate which might include many contingencies. Since the Government does not like to include costs for things that might not happen in the cost estimate base, some form of pricing arrangement is needed to exclude these contingencies. An incentive contract is a very good solution to the problem.

The limit on fee in a cost type contract might not be an indusement for the contractor to consider an incentive contract. The Government, if faced with this problem, should consider the use of a fixed price incentive (FPI) contract instead of the CPIF contract. The profit limit for the FPI is not limited and can be negotiated. The contracting activity can develop a reasonable target profit by the use of the Weighted Guidelines Method. We all recognize that the profit rate that we arrive at by this method is only a starting point for negotiations. This starting point will be adjusted during the negotiations to reflect the flow of information which will take part. The sharing arrangement and the ceiling price for the FPI contract can be worked out during negotiations to provide the Government with the measure of protection the contracting activity requires. In addition, at the same time, the FPI arrangements assures the contractor the degree of security and profit that is needed before the contractor will accept the terms of the contract. The following graph (Figure 2) is not graphed to demonstrate the FPI contract, but can be adjusted by the reader to reflect that type of arrangements.

Figure 2




It should be noted that there is no slope between #1 and #2. On that line the fee/profit does not change when the cost rises between point #1 and #2. There is what can be classified as a Cost Plus Fixed Fee contract between #1 and #2. When the cost exceeds point #2, the contractor must share costs from the fee/profit pool at the rate of 50 cents per dollar. If the contractor can reduce costs to the left of point #1 on the graph the contractor's fee/profit will increase at the rate of 50 cents per dollar saved. In Figure 2 the fee/profit is $116,666 at any point on the line between point #1 and point #2 (Between cost points $1,166,666 and $1,375,000 of costs). Fee/profit dollars change only after the cost exceeds $1,375,000 or when the contractor reduces costs below $1,166,666. This parameter provides an incentive arrangement which can promote the contractor to remain on the plateau or to underrun costs.

RECOMMENDATIONS

It is strongly recommended by this author that the functional contracting offices of the military services and civilian agencies aggressively promote the fixed price incentive contracting method to obtain agreements in very difficult negotiations. The use of fixed price incentive contracts with an upturn in the share line between a strong Government position and the contractor's position should seriously be considered. The splitting of the difference or yielding to the position on costs promoted by the contractor may not be in the best interest of the Government. In lieu of the flat cost plus fixed fee plateau noted in Figure 2 a shallow sharing arrangement of 95/5 or 90/10 could be negotiated.

Again there would be some incentive even on that shallow slope to save money. The negotiation of a 60/40, 55/45 or 50/50 under and overrun sharing arrangement for the balance of the incentive is necessary to provoke contractor interest in cost management. There can be substantial benefits that can be derived during contract negotiations from changing contract types. This vehicle should be used in situations where uncertain contractor costs projections will far outweigh any objections from management or other considerations. Management should examine these situations and recognize that fixed price contracts do not protect the Government's best interests and must not always be negotiated. It is important for everyone concerned to keep negotiation options open. Changing contract types might prove a useful tool in negotiations for the Government.

MULTIPLE MANAGEMENT OBJECTIVE FEE CONTRACTS (MMOFC)

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## ABSTRACT

This research paper explores how the conventional contract formats have been used for the operation and maintenance of the U.S. Army Ammunition Plants and the success of these contract formats to accomplish the objectives of the Army. The paper will provide data on what types of contracts are currently being used and what value they have been as tools to obtain good performance by the contractors. This will be followed by some of the problems that have been experienced in the use of some of the types of contracts at contractor operated facilities.

The author has studied in great detail the needs of the Government and has developed a couple of new contract types specifically designed for the management of the Army Ammunition Plants. These contracts, although designed for use in contracting for the operation of the Army Ammunition Plants have general application.

Under the Department of Defense Pilot Contracting Activities Program (PCAP), the Department of the Army has approved the test use of three of these Multiple Management Objective Fee Contract (MMOFC). This paper will explore the need for this contract, the advantages of the MMOFC over the Cost Plus Award Fee and Cost Plus Incentive Fee contracts.

The paper will conclude with recommendations for expanded use of the MMOFC following the test. The author believes that the MMOFC contract is well suited for many Commercial Activities type contract arrangements.

## INTRODUCTION

The management of the US Army Ammunition Plants and the award of contracts to private industry to manage these contracts has been a problem. Over the years the Government has used the Cost Plus Fixed Fee contract to operate these Government Owned Contractor Operated (GOCO) facilities. In recent years there has been an effort to negotiate contracts to perform the required production, maintenance, etc. at the ammunition plants before the beginning of the performance period. The contractor is required to develop their cost base proposal on an anticipated scope. The cost base proposal is submitted to the Government which spends many months to evaluate the proposal, audit available data, and then begin negotiations. The objective is to have a definitive contract negotiated prior to the beginning of the contract year. In many cases only part of the scope of work negotiated will be funded at the beginning of the contract period.

This sounds simple enough and would be if the proposed scope of work provided the contractor many months before the contract year began was the scope of work that is actually performed. The problem is that the scope will change several times before the negotiations are completed. Then after the negotiations have been completed and the contract is signed many additional changes will evolve. Some of the changes are caused by changed requirements, change in sequence of production, late Government Furnished Property (GFP), etc. These changes are frequent and in a normal situation would require continious negotiations on the part of the parties to achieve equity.

The situation which exists at the Army Ammunition Plants is not unique. It is the policy of the US Government to make periodic reviews of its operations to determine if the Government should continue to operate a commercial-type activity or if the Government's needs would be better served by contracting out that operation. The policy covering this process is promulgated by the Office of Managemet and Budget in Circular A-76. When it is determined by the Government that a facility will undergo a "cost comparison," a group of designated employees of that activity must develop an all encompassing scope of work (Statement of Work) that identifies what each of the parties must do to operate, maintain, and in some cases, determine what product must be produced. The Government then issues a solicitation to industry, and at the same time, the Government employees develop an "in-house proposal" to perform the work complying with the scope of work set forth in the solicitation.

Contractors exhibiting an interest in competing for the operation of the commercial activity assemble their proposals for the work and submit those proposals to the Government in the form of a sealed bid or proposal. The results of the submissions by private industry are reviewed and compared, and the apparent low evaluated price is determined. At a prespecified, exact date and time, the Government's proposal is formally opened, and a comparison is made with the apparent low proposal submitted by the prospective contractor. In the event the Government is determined to be the most cost effective operator, no contract award is made, and the Government assumes or continues operation of the facility as a Government-owned, Government-Operated (GOGO) facility. In nearly all cases, the Government operation is scaled down and streamlined to the scope of work. If, after all factors are considered, the contractor's price is considered the lowest, most economical price, a contract is awarded, and the operation then becomes a Government-owned, Contractor-operated (GOCO) facility.

## WHAT IS THE PREFERRED CONTRACT TYPE?

The most favored type of contract resulting from these commercial activity reviews is a fixed price contract. To be most equitable to all the parties, a fixed price contract is almost mandatory. However, the scopes of work that are developed to perform the work at these facilities occasionally do not support a fixed price type contract. Why? Because of unforeseen situations or poor estimates of the amount of maintenance on the part of the Government and additional work that comes about during the course of performance of the contract. The variety and the nature of these changes make fixed price contracts difficult, if not impossible, to administer. These deviations from the original scope of work are what necessitate the renegotiatin of the scope and causes a dollar impact to the contractor. During this renegotiation phase, the fixed price contract becomes a cost plus type of contractual arrangement until the negotiations are complete and an equitable adjustment consummated.

## TYPICAL PROBLEM

The Government has negotiated a contract to operate a Government facility. The contractor is provided the scope of work which identifies the work or services to be performed. Let us establish a hypothetical case where trucks, trailers, and wheel barrows are to be manufactured. The Government has provided the contractor with the facilities, and the contractor's responsibility is to hire and compensate workers to perform the necessary production work. The contractor is contractually obligated to purchase only the raw materials that are required to manufacture specific components that the facility is designed to make or are otherwise specified by the contractual agreement. In our example, the rubber tires, motors, transmissions, drive shafts, axles, and the electrical wiring items are all supplied as Government Furnished Property (GFP) to be incorporated into the trucks, trailers, and wheel barrows to be produced at the GOCO. For the purpose of this hypothetical case one of the contractor's who the Government has purchased axles from has become delinquent. This delinquency has a direct effect on the Government's ability to provide the GFP to the manufacturing contractor at the GOCO facility. Depending upon which stage in the production effort the GOCO contractor has reached, the exact magnitude of the cost change, etc., makes a contract adjustment necessary. The adjustment must be agreed to by both parties when the Government breaches the contract. The "Changes" clause which would be in the contract (the applicable one from the Federal Acquisition Regulations (FAR) Part 52) would not provide the vehicle for making this adjustment. The non-delivery of GFP is just one of the many situations that happen during the performance of GOCO contracts which requires a contract adjustment.

In another situation the Government may want to change the production scheduling of the products being produced. For example, if the contractor was making 5.56mm ammunition and the Army wanted 7.62mm ammunition delivered before the 5.56mm we have a change to the contract delivery schedule. In this example the contractor would be entitled to an equitable adjustment to the contract for the economic and schedule impact. The change can not be accomplished under the changes clause of the contract, but must be made with the mutual agreement of the parties. The contractor can claim and receive an equitable adjustment to the contract price. The contractor could demand that the negotiation be conducted prior to the change. Under a cost type contract, the contractor would work to the changed contract and seek an adjustment to the estimated cost and fee after his work had commenced. In a fixed price contract the contractor might not perform the work prior to the negotiations.

From my years of review of the GOCO and other Commercial Activities contracts, the Government seldom covers all the contingencies that evolve during contract performance. This requires many contract modifications and cost growth to cover these situations. Over the years the Army has handled these situations in Army Ammunition Plant GOCO's by negotiation of a Cost Plus Fixed Fee contracts with provisions for no fee adjustments if the work to be performed increased or decreased by 10 to 15 percent from the estimated costs negotiated. This was a reasonable arrangement. In addition, the fees negotiated for the ammunition plants was in the range of 3 to 4.5 percent of the initial negotiated cost base.

When the Government ventured into the Cost Plus Incentive Fee contracts several years ago, many mistakes were made. In one of these contracts, the contractor reduced the maintenance level after the contract was negotiated. This caused some damage to facilities, but the contractor was able to reduce costs and achieve maximum incentive. In another situation the contractor and the Government negotiated a Cost Plus Incentive Fee contract with an incentive fee range of effectiveness of plus and minus 5 million dollars. For every dollar the contractor saved his fee would be increased by 40 cents. The target fee was 4 million dollars with a maximum fee of 6 million dollars and a minimum fee of 2 million dollars. The Government did not want to open the incentive contract arrangement to further negotiations because of additional work so the Government provided that all additional work would be awarded on other contracts. The other contracts were Cost Plus Fixed Fee contracts. The one thing which everyone overlooked in the negotiation of the Cost Plus Incentive Fee contract was that all work that is performed in the GOCO would share a fair share of the fixed and semi-variable overhead costs. Thus, the increased production placed at the GOCO and not added to the incentive contract reduced the cost base shared by the incentive contract. Thus, by this reduction in overhead costs caused by the added work could have masked an overrun situation on the incentive contract and the contractor could realized maximum incentive. The essential element is the dilution of the overhead accounts. How can this be precluded? Only by incorporation of all new work into the incentive contract. In addition, the incentive contract must be one under which the work awarded must be completed during the performance period of the contract. Some of the incentive contracts were negotiated to cover the anticipated work for a one year period of time. The contractor who could delay the work into the future period of time could then underrun costs and gain a higher fee by not performing work during the covered period. This happened on several contracts. It is recognized that this came about by poor administrative practices of the US Army and the personnel placing and negotiating the contracts.

## FIXED PRICE CONTRACT NIGHTMARE

Some bright General officers have heard that fixed price contracts are the answer to all of our problems at GOCO's. The situations that are outlined above come to pass under the fixed price contract. You can not contract for a year period of time because it becomes a best effort fixed price contract. Delays in GFP or change in schedules require adjustments to the contract price to be negotiated. Fixed price contracts have been evaluated by the General Accounting Office and found not to be in the best interest of the Government. If a contract could be awarded for each item required and the performance period of the contract to run until all products are delivered then a fixed price contract is practical. But no change to the schedule could be made and a level production rate would be required for all products to preclude the contractor factoring his price for projected sales.

## WHAT IS NEEDED?

The question of what kind of contract is ideal for the operation of a GOCO is a difficult one to answer in a few words. A contract that has the flexibility to meet the demands of constant changes and yet provide an incentive for the contractor to perform well is that ideal contract type. Some contractors, like those Department of Energy contractors who operate laboratories, often are not paid a profit or a fee. Their corporate benefit is from the research that can support advances in their consumer product lines or advance the "state of the art" which will indirectly aid their corporate product lines or add new products to their commercial business. Most contractors, however, want to make a profit to add to the corporate income statement. Thus, the current contract types with the FAR clauses that exist do not provide the needed flexibility because they require constant adjustment to both target costs and fee or, in the case of fixed price contract to the total price of the contract. What is needed is a contract that is flexible, allows for work changes and delivery revisions, increase in quantities to be produced or changes to the scope of work within predetermined guidelines without a corresponding change in the profit or fee structure that is applied. The current contract types that are used in the GOCO operations do not facilitate the latitude of flexibility that is desired and, in most cases, needed by the Government to manage these industrial plants.

Many officials in the Army know that the Army Ammunition Plants must be flexible to meet the demands of troops and friendly foreign country customers. No current contract provides that latitude of change without an equitable adjustment being required. This author has investigated this situation and has discussed with managers of the General Accounting Office in Chicago the following concept. The idea is a Fixed Price Management Contract. This contract would be negotiated for the contractor's management effort required to manage the production effort at the GOCO facilities. This fixed price contract would cover a period of time. It would cover a level of effort. The production, maintenance and other work required to meet mission demands would be performed under a Cost no fee contract. Since all the salaries at the GOCO plant, and all other costs would be covered under the Cost contract, the Fixed Price contract would constitute the profit the contractor would earn for the intangible called management expertise. The structure of the contract would exclude adjustments to the price because of changes within a range of plus or minum 15 percent. The adjustment could be prenegotiated based on a formula. The cost base of the Cost no fee contract could be based upon budget estimates developed by the Government or the contractor and the Government. Much of the cost data is available to the Government from history and audit of the contractor's cost. The Fixed Price Management Contract could include an incentive arrangement to get management attention to certain cost areas. This type of contract has been discounted by Headquarters, US Army Materiel Command in Washington, D.C. The author believes that this is short sighted on their part and comes from a lack of understanding of the operations of the GOCO's. In addition, the cost savings that would accrue to the Government by not negotiating the cost base would amount to hundreds of thousands of dollars each year. This concept will only be tested when the Department of the Army gets a leader who is willing to to test this concept.

One of the reasons that this concept has minimum risk from the Government's point of view stems from the following example:

The Government needs to increase the rate of production of a product that might be the mission of the GOCO. For instance the Government requires the contractor to produce 2,000 pounds of TNT a month instead of the planned 1,500 pound forecasted at the beginning of the year. The process requires that the batch sizes be increased or additional batches to be mixed. In most cases, the only additional effort that is required is increase in the quantities of raw materials that are purchased and some additional packaging and shipping effort. In most cases the people currently employed at the plant would be able to meet the increased rate of production. The additional management effort is minimal, if any, for this production.

Under the current contract types used in the management of the GOCO's the increase of quantities would require a supplemental agreement to be negotiated with an adjustment to the estimated cost and additional fee. Only in the situation where a Cost Plus Fixed Fee contract existed with a concept called "triggers" would no adjustment be required. In these contracts the Government and contractor have agreed that no adjustments will be made unless the adjustment in work exceeds 10 or 15 percent plus or minus work over what was originally negotiated in the cost base of the contract. In the situation where this trigger did not exist then the contractor would have to prepare a proposal, that proposal would need to be evaluated, audited, and then negotiated. What is needed is a contract (like that described above as a Fixed Price Management contract with a companion cost no fee contract) with flexibility. The contract that would provide for additional work and the adding of production workers up to a ceiling of 50 employees in addition to extra work without adjustment of the fee/profit of the contract. The only change necessary would be an increase in the Government's limitaton of cost to cover new or additional work.. The cost base increase would be established based upon historical data that is available to the Government in most situations or from a budget estimate that the contractor would provide upon request by the Government.

COST PLUS AWARD FEE CONTRACTS

Under the current provision of the FAR, we can negotiate Cost Plus Award Fee contractors to provide a contractor an incentive to perform against established incentive criteria. The intended results are improved performance in areas where the Government believes that improvement is needed or in areas where emphasis by the contractor is needed to preclude problems (e.g. safety, security, and quality). The evaluation process for these contracts permits the contractor to provide the Government with an evaluation of their own performance. This evaluation is, in many cases, a detailed synopsis of the contractor's impression of great performance and amounts to hundreds of pages of good stories and examples. The Contracting Officer's Representative, a person who heads a staff of Government employees who review the day-to-day operations and performance of the contractor at the work site, also prepares a detailed evaluation of the contractor's performance against the established criteria. This is a subjective evaluation open to judgment calls by this staff.

These two evaluations are normally reviewed by a Cost Plus Award Fee Borad which meets and reviews the evaluations and then arrives at some percentage to apply to the performance. This is translated into dollars from the fee pool by the Fee Determining Officials. In 99 out of 100 cases, the Board's determination becomes the percentage of the fee pool that is awarded the contractor. The author has chaired many of these boards and has discovered that an overall rating of between 85 to 95 percent of the total fee pool is normally awarded to the contractor for the evaluation period. Further, there is a tendency, over time, for evaluations to creep higher. Thus, in the first year if the contractor is awarded 86 percent of the fee pool, the next year it will be 88 or 89 percent and eventually will creep into the 90 percent range.

Notwithstanding this creep, there is a reluctance on the part of many contractors to accept the subjective nature of the Cost Plus Award Fee contract authorized for use by the FAR today. The reason for this reluctance is the fact that the evaluation is subjective and not open for challenge. The contractors fear that contracting officers or other people in the Government will unjustly evaluate their performance. Some contractors feel that there is a basis for this concern in factual situations based upon their years of experience. The author has seen some of these situations in my years of experience on evaluation boards. Of course, I must state that there has been situations where the contractor was given a higher rating than I believed was appropriate. Contractors do not see the mitigation efforts of the board as working in their favor. What the contractors desire are definitive goals or objectives and the right to appeal the fee assessments based upon questions of fact.

The author, after considerable evaluation of the efforts of contractors and the desires of the Government, has reached the conclusion that an "objective award fee contract" could be developed and utilized. Since the Government in GOCO contracts are dealing with services, maintenance, wild life management, and general contractor performance elements, the normal multiple incentive contract is not applicable. The normal Cost Plus Incentive Fee contract with multiple incentives is negotiated for the improvement of the performance of the deliverable end product. It is the authors educated opinion that the normal Cost Plus Incentive Fee with multiple incentive elements is not applicable to GOCO contracts as are currently negotiated at the Army Ammunition Plants. What are the usual desires of the Government for the contractor to operate any Government facility? The Government wants the contractor to manage costs, produce a quality product, or perform the services outlined, perform the work safely, and maintain the Government equipment without causing excessive wear or damage to that equipment.

MULTIPLE MANAGEMENT OBJECTIVE FEE CONTRACTS

The development of a concept that would set up objective criteria is not new. Multiple Incentive contracts have been used in the Cost Plus Incentive Fee area for years. These incentives are normally limited to performance of the product being produced. In these situations there is a value statement developed with cost trade offs against product performance incentives. But what is needed in the management of Commerical Activities and Government Owned Contractor Operated facilities is objective elements requiring the contractor to produce acceptable lots of product at least 98 percent of the time, thereby providing a reduction in the fee pool in the event that the contractor has rejection rates of 97 percent or more. The same type of consideration could be applied to equipment maintenance or safety. The key in any of these contracts is that the areas where poor performance has been a problem is where incentives need be considered. To have ten areas with three and four sub-elements only dilutes the incentive pool to a point where there is no longer any incentive. The objective criteria of the MMOFC and the applicable rating would not require convening of an Award Fee Board. The statistics that are generated during the performance of the contract would be matched aginst the standards, and a numerical rating calculated. The contracting officer would only have to compute the allowable fee from the application of statistics against a table and modify the contract for payment of the earned fee. This feature would eliminate the cost of preparing the contractor and Government subjective evaluations for the Cost Plus Award Fee Board. If we can equate a page of data to be worth $25.00 of cost and then multiply that by the hundreds of pages normally developed by both parties, the savings that could result would be tens of thousands of dollars. In addition the savaing of time of high priced Government managers who participate on Cost Plus Award Fee Board. In a Cost type contract, the contractor's costs to prepare the self evaluation are passed on to the Government as an allocable and allowable cost of contract performance.

In the Multiple Management Objective Fee Contract (MMOFC) cost management must be a large and key element in the evaluation process. This element serves to preclude the contractor from failing to halt runaway costs in the production of product, maintenance of facilities and equipment, etc. The other elements such as safety, securty, production quality, timely delivery, timely service, quality of service, etc., can be evaluated against objective criteria. Statistical guidelines can be developed, a ranking against these criteria can be made by the contracting officer, and the contractor can be paid an appropriate fee as determined from the prior negotiated arrangement. In the event there is a disagreement, the contractor could dispute the questions of fact that are creating the differences of opinion, and a judicial remedy could apply.

PILOT CONTRACTING ACTIVITIES PROGRAM

The author tried to get approval of the Army Materiel Command (AMC) on a deviation to permit the US Army Armament, Munitions, and Chemical Command (AMCCOM) to use a Cost Plus Award Fee (Objective) contract. The request was received by AMC and they rejected the concept. They did not like the feature which would allow the contractor to dispute the evaluation. AMC did take a while to reject the idea outright. When the Pilot Contracting Activities Program (PCAP) was implemented, the author was appointed the PCAP coordinator for AMCCOM.

The PCAP program provided that commands could forward requests to the Department of the Army (DA) directly without going through AMC or other commands. These requests were for ideas and concepts which would eliminate bottlenecks, make procurement more effective and efficient, lower approval levels, etc. The limitation which was applied to the requests were that the requests could not be for elimination or change of regulations which had their basis in statute law or resulted from Executive Orders of the President of the United States. If the idea or concept did not infringe in these aforestated areas then the ideas could be considered on their merit and discussed at DA for approval. If the concept was approved the approval would be for testing of the idea for a period of time witn periodical reports on the results. If the idea saved money or improved the procurement process then the idea would be adopted as a change to the FAR or the Defense Federal Acquisition Regulation Supplement (DFARS).

Many suggestions were forwarded to eliminate certain levels of approval, raise the dollar approval levels of such things is "Letter Contracts" and other documents. Some ideas were not approved but 65 percent of the concepts were appr[illegible]ed for testing.

One of the suggestions tha[illegible] was developed by AMCCOM and the author was the u[illegible] of the Cost Plus Award Fee (Objective) contract. The one that had been disapproved by AMC earlier. The request was received and reviewed by the Department of the Army and they did not object to the concept. They did not like the title that had been given to the contract type. Cost Plus Award Fee (Objective) contract was very similar to Cost Plus Award Fee contracts. It was recommended that a new title be developed. After long discussions between the author and DA on why the contract type was needed there was not question on the need of this type of contract. Following several months or thought, the author came up with the name "Multiple Management Objective Fee Contract (MMOFC), and the Department of the Army liked the new name. The Department of the Army then approved this type of contract for test for a period of one year (later extended to a two year period of time). The Army limited the test to three contracts and wanted a copy of the contracts written and the criteria. The results of the test of the contract type were to be provided to DA as soon as the data was available.

The Air Force called AMCCOM to discuss with the author the concept. The Air Force was on distribution for the message traffic on the contract type request, but they wanted to know more information. I do not know if the Air Force has requested use of a similar contract as of the writing of this paper, but they had an interest.

WHAT ARE THE USES OF THIS CONTRACT?

The MMOFC could be used very effectively for "Base Operations Contracts" awarded under the Commerical Activities program. Any contract awarded after a "cost comparison" could utilize this concept. It is more cost effective than a normal Cost Plus Award Fee contract. It is a type of contract which the contractor can feel more comfortable performing under.

RECOMMENDATION

The use of the MMOFC contract should expanded to the Department of Energy in the management of their GOCO's and to other military services beyond the Army. A broad base test will validate the cost effectiveness of this contract and will far outweigh any risks that might be experienced. This contract type could save many thousands of dollars in pre-contractual costs on the part of both the Government and the contractor. One estimate is that there might be as much as $500,000 savings per contract on the large, hundred-million dollar GOCO contracts. These figures mandate that serious consideration be given to the idea. It is recommended that efforts be undertaken to add the MMOFC con[illegible] to the FAR. The Fixed Price Management Contract outline earlier in the article should also be seriously considered by the services. It is recognized that a departure of normal operations will result, but the savings are substantial by using this contract at GOCO's.

# SIMPLIFIED COST PLUS AWARD FEE (CPAF-S) CONTRACTS

by

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## ABSTRACT

Cost Plus Award Fee (CPAF) contracts have proven successful for the federal government in the acquisition of both hardware and professional services. They provide a means, by periodic evaluation and payment of Award Fee (AF) dollars, to motivate contracts to superior performance. Administrative difficulties for the program office staff and other participating managers have discouraged broader use of CPAF contracts.

A simplified award fee approach is proposed, which would be called Simplified Cost Plus Award Fee (CPAF-S) contracts. The elements of the CPAF contract that would be simplified are (1) evaluation periods, (2) evaluation factors, (3) the award fee determination official, and (4) the AF determination procedure.

It is proposed that standard quarterly evaluation periods be used for CPAF-S contracts. Four general factors: (1) technical, (2) cost, (3) schedule, and (4) management would be evaluated. Only the Project Manager (PM)/Contracting Officers Technical Representative (COTR)/Award Fee Determining Official (AFDO) and the applicable Contracting Officer would be involved. The proposed procedure would call for a report by the Contractor to the AFDO within 10 working days after the end of an evaluation period/quarter. By the 21st working day following the end of the evaluation period, the AFPO would have solicited telephone input from his staff and participating managers. On the 21st working day following the end of the evaluation period/quarter, the AFDO would provide the Contracting Officer a memo report on his AF evaluation. Within 31 working days following the end of the evaluation period/quarter, (1) the Contracting Officer would issue an administrative amendment providing the Contractor with the applicable award fee dollars and (2) the AFDO would provide the Contractor with a short (five pages or less) report on the contractors performance for the applicable quarter.

This simplified AF approach should encourage greater use of incentive contracts and streamline existing AF procedures.

## BACKGROUND

Cost Plus Award Fee (CPAF) type contracts have been an approved and accepted type of federal contract since the late 1960s. This type of contract has been used for major systems acquisition, like the lead ship CG-47 Class AEGIS Cruiser, and for Research and Development (R&D) and professional services efforts. The contract calls for an optional 1-3% base fee and an award fee, with total fee limited, as with any cost-type contract, at 15% fee for R&D and 10% for non-R&D efforts.

Federal Acquisition Requirement (FAR) 16, 404-1 suggests application of CPAF contracts for use when:

(a) it is neither feasible nor effective to devise predetermined incentives for the work to be performed

(b) acquisition objectives can be enhanced by using a contract that motivates the contractor towards exceptional performance

(c) administrative effort and cost required to monitor the contract can be justified

(d) the evaluation criteria will differ widely among contracts

(e) evaluation can be provided at stated intervals so that the contractor can be informed of the quality of its performance and partial payment of award fee can correspond to the evaluation periods and content.

Like most government incentive contracts, there have been many proven advantages for using CPAF contracts. Many Navy AEGIS program personnel, including Rear Admiral Wayne Meyer, USN (now retired), the AEGIS Program Manager, feel that the USS TICONDEROGA (CG-47) was delivered on time and within cost goals because of the use of a CPAF contract for the design and construction of the lead ship. In the shipbuilding arena, contractors are provided AF incentives for technical, cost, schedule, and contract management factors. The award fee grading scheme and dollar pool have historically been constructed to motivate the contractor in different ways during the life of the contract. Because technical and schedule factors are very important during the early periods of ship design and construction, technical and schedule AF factors have and can be developed to heavily apply award fee dollars to those factors in the early quarters of the contract.

One of the true values of AF contracts is that it provides the contractor with a periodic report card as to the contractor's performance under the contract.

CPAF contracts have also proven successful in engineering and professional service contracts. The omnibus engineering and professional service contract for support of the Navy Amphibicus Ship Acquisition Program (PMS-377) in the Naval Sea Systems Command is another success story. With the help of their AF motivated program support contractor, PMS 377 was able to simultaneously start the LSD-41, LCAC, LHD and the LSD SLEP Programs.

There is also a new and interesting discovery concerning the value of CPAF contracts when used for professional service requirements. Limited research has shown that, although CPAF contracts for engineering and professional services do not earn as much fee/profit for the contractor as a similar Cost Plus Fixed Fee (CPFF) contract, contractors tend to manage CPAF service contracts better because the earned fee or profit is variable versus fixed as with CPFF.[2] By managing the CPAF contract well (personnel assignments, monitoring costs, etc.), the contractor may be able to achieve a 6 1/2% to 8 % award fee versus a 3 1/2% to 5 1/2% earned award fee if the contract is not managed well.

## ADMINISTRATIVE PROBLEMS WITH CPAF CONTRACTS

Many DoD contracting and program management personnel have advised during training courses that they would like to make more use of CPAF contracts, but that the government does not have the time, people, and dollars available to administer a normal CPAF contract. This constraint relates directly to the third consideration of FAR 16.404-2, concerning the cost and and administrative effort involved with using CPAF contracts.[3] But where does the cost of administering these contracts CPAF come from?

Historically, on large CPAF contracts (either for systems or services), the Contractor makes a periodic presentation (usually quarterly) to the Program Manager, Contracting Officers Technical Representative and/or the Award Fee Determination Official and their staff regarding the Contractor's perceived performance during the preceeding evaluation period. Such a report would relate directly to the evaluation factors in the applicable CPAF contract (technical, cost, schedule, management, etc.) The contractor report may be submitted in conjunction with a contractually required Quarterly Program Review (QPR) or not. The PM/COTR/AFDO then provides the contractor with a detailed verbal and written summary of the contractors performance during the particular quarter or period in the contract. These summaries take many government man hours to prepare. A separate report is made by the AFDO to the applicable contracting officer for preparation of an administrative amendment that provides the applicable award fee dollars to the contractor. The government's award fee determination is not an appealable issue in the contract.

While the give and take on the part of the contractor and the government during the AF process is very worthwhile from a contract management point of view, it results in many hours of work on the part of the government PM and his staff and other participating government managers to feed AF information to the PM/COTR or AFDO. Although the AF determination is not subject to appeal, the AFDO wants to be very sure that the government's determination is reliable and fair. Again, because of the time and cost necessary to properly administer a CPAF contract, PMs and other users chose a CPFF or Cost Plus Incentive Fee (CPIF) vehicle for their requirements.

## RECOMMENDED SIMPLIFIED APPROACH

The purpose of this paper is to introduce a new type of CPAF contract for consideration for Department of Defense (DoD) and federal government use. Although CPAF contracts have proven to be very worthwhile vehicles for motivating superior performance from hardware and professional service contractors, some effort needs to be made to reduce the administrative difficulty associated with the use of these contracts. A Simplified Cost Plus Award Fee (CPAF-S) contract is proposed. The new CPAF-S contract would be simplified regarding (a) evaluation periods, (b) evaluation factors, (c) number of government players (AFDO) involved, and (d) the specific award fee determination procedure. Each of these four aspects will be discussed separately.

(a.) <u>Standard Evaluation Periods</u>. Experience has shown that the government needs to appraise the contractor early after the end of an evaluation period in order to allow the contractor time to make performance adjustments. On the other hand, monthly or frequent evaluations result in a continual appraisal process which is administratively burdensome for both the government and the contractor.

A standard quarterly evaluation is proposed for a number of reasons. First, most large contracts call for a quarterly program review. For those AF contracts, the award fee evaluation and determination can be performed in conjunction with the QPR. Second, if longer evaluation periods are used (like every six months or once a year), contract problems may be locked in concrete by the time the evaluation is received by the contractor. Quarterly evaluations can allow the contractor to make mid-course corrections in a timely manner. Third, quarterly evaluations allow contractor corporate managers to see the fruits of their efforts when they can see and feel the quarterly award fee check.

One large professional service firm holds its own internal quarterly performance review after each award fee grade is received, with the objective of improving performance in order to earn a higher award fee grade the following quarter. **Here we have one of the basic objectives of award fee contracting, i.e., encouraging the contractor towards superior performance.**

(b.) **Simplified Award Fee Evaluation Factors.** It would be easy but foolish to propose that all AF contracts be measured with the same evaluation factors, subfactors, and elements. However, with CPAF-S contracts, it is proposed that the four main factors (technical, cost, schedule, and management) be standardized so that both the government and industry can have a consistent convention to use in working with CPAF-S contracts.

Technical is a broad factor that can be used by the PM or COTR as desired or needed. In small ($1 million - $10 million) CPAF-S hardware development contracts, the PM or COTR can measure the contractors engineering or manufacturing performance. Quality assurance and/or quality control could be a measure of the contractors technical/manufacturing performance. In professional service contracts, the quality of deliverables or engineering work could be observed and graded. An overall technical score is recommended versus graded subfactors or elements.

Cost performance could be measured relative to a contractually required cost schedule or plan that would be provided to the PM or COTR. Cost performance relates directly to schedule performance. However, it is feasible for the PM or COTR to grade the contractors overall cost performance. Subfactor costs, like labor cost, or element costs, like design engineering labor, can be developed based on the needs of the PM or COTR. However, an overall summary grade for cost is realistic and therefore recommended.

Schedule performance will be a more important AF factor in hardware contracts than in AF service contracts. The PM or COTR will need to monitor the contractors proposed schedule or the schedule that may be called out in the contract and can grade the contractor accordingly. Subfactors and elements can be used for grading schedule issues but they are not recommended for CPAF-S contracts. **The idea is to keep the AF features simple and easy to administer.**

The management performance factor is considered by many to be a catchall factor. The question may be "How well is the contractor managing this contract?" "Is the contractor manning the contract properly?" "Are engineering changes being adjudicated quickly?" "Are engineering change proposals being worked in a cooperative manner?"

This factor gives the PM/COTR or AFDO a chance to generally measure the contractor on adminstrative or managerial orientated performance issues. Again, an overall management grade is recommended.

It is only fair to expect that the PM/COTR or AFDO will be able to provide the contractor with a general short written summary of its performance. Arbitrary or unfounded low or high grading in a CPAF-S contact can have a countervailing or reverse effect of "turning the contractor off" from a motivational viewpoint and can lead the contractor to believe that it will receive a certain grade, whatever the contract performance. It is critical that the evaluation be realistic and valuable in order that the CPAF-S contract can be effective.

(c.) **Simplified Award Fee Determination Officials.** One of the biggest administrative savings in the proposed CPAF-S contract is that only one or two government officials are involved in the award fee determination process. In many cases, the PM or the COTR will be the AFDO and will determine the AF grade. If no PM or COTR are assigned, the Procuring

Contracting Officer (PCO) or Administrative Contracting Officer (ACO) may also serve as the AFDO. As is the normal AF procedure, the AFDO will provide the applicable contracting officer with the AF determination/score and the contracting officer will issue an administrative amendment providing the contractor with the applicable award fee dollars.[4]

(d.) **Simplified Award Fee Determination Procedure**. One of the keys to a simplified AF contract is the manner in which periodic award fee determinations are made and transmitted quickly to the contractor. As in the case with regular AF contracts, the award fee determination in a CPAF-S contract is not a appealable issue in the contract.

The following is a recommended standard simplified award fee procedure that would apply to CPAF-S contracts with quarterly evaluations:

(1.) Within 10 working days following the end of each evaluation quarter, the Contractor will provide the AFDO with a short (no more than five double spaced typed pages) report on the contractor's perception of its technical, cost, schedule, and management performance during the proceeding quarter. The report is optional on the part of the contractor. The contractor would include items wherein the government may be hindering the contractors successful performance of the contract (like overdue drawing reviews).

(2.) Upon receipt of the contractors AF report (or after 10 working days following the end of the quarter, if there is no contractor's AF report), the AFDO will make telephone calls to key government players in the program office and/or to participating mangers supporting the applicable AF contract. These calls will allow the AFDO to informally pulse his/her system to receive verbal comments regarding the Contractor's technical, cost, schedule, and management performance. If major cost, technical, schedule, or management issues arise, a clear example of the issue should be noted. In this regard, it is suggested that the AFDO record positive and negative feedback received from his system. General comments are acceptable, but the AFDO should be able to receive a good understanding as to how the contractor is performing. If the AF determination process occurs in conjunction with a QPR, the PM or COTR may wish to discuss the AF performance issues directly with the Contractor, as part of a PM's role.

(3.) On the 21st working day following the end of an evaluation period/quarter, the AFDO will provide the applicable contracting officer with a memo report on the AF determination for the contractor for the preceeding quarter. The report will provide the grades for the particular factors evaluated during the quarter involved.

(4.) Within 31 days following the end of an evaluation period/quarter, the applicable government Contracting Officer will issue an administrative amendment to the contract providing the applicable AF dollars to the contractor.

(5.) Within 31 days following the end of an evaluation quarter, the AFDO will provide the contractor with a short advisory report card concerning the contractors AF performance during the preceding quarter. This report will be no more than five double-spaced pages. If the AFDO, PM/COTR, or the contractor feel that major issues regarding the performance of the contract have been raised by the AF evaluation, either party may request a normal contractor/government meeting, but such meeting will not be related to nor will discussions be held regarding the applicable AF determination.

**SUMMARY**

In summary, a new Simplified Cost Plus Award Fee (CPAF-S) contract is being proposed. The AF evaluation period would be standardized at a three month interval. Technical, cost, schedule, and management evaluation factors would be used with a strong recommendation that subfactors and elements not be utilized. The AF determination process would be handled solely by the AFDO and the applicable government contracting officer. A tight but reasonable AF determination schedule would be utilized to complete the process in a timely manner to allow the contractor to adjust contract performance, if necessary.

This new CPAF-S contract approach is recommended to encourage greater use by the federal government of incentive contracts and to encourage general streamlining of government contracting efforts.

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